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The Loetschberg Tunnel.

By E. L. CORTHELL,* M. Am. Soc. C. E.

Ever since the opening of the Simplon Tunnel, connecting Switzerland with Italy, the necessity of opening up a route of access to it from the north and northeast of Europe has been apparent. Even before the Simplon Tunnel was undertaken, in fact for the last 20 years, influential interests at Bern had urged the piercing of the "Bernese Oberland." Several routes have been proposed for getting through the Oberland, which lies between Bern and Brigue at the northern entrance of the Simplon. The two routes that claimed most attention were those under the Wildstrubel and the Loetschberg. The former passes up a valley and over a railroad already constructed to Schwarzenburg, and from there under the mountain to the valley of the Rhone, connecting there with the line from Martigny to Brigue. It would have passed under the Oberland some distance west of the Loetschberg Mountains.

A commission of three eminent engineers, Messrs. Colombo, Pontzen and Garnier, representing Italy, France and Belgium respectively, was called to study the whole question and report. They reported in favor of the Wildstrubel route, but local interests, specially that of Thun, were sufficiently powerful to decide in favor of the Loetschberg.

The general location of the Loetschberg Tunnel and its rail connections are shown by the map Fig. 1.

It was the privilege of the writer in May last, and again in July, to make quite careful examination of the tunnel now under construction, and of its northern approach between Frutigen and the tunnel, and to learn much of interest connected with the project and the work itself. Through Mr. Chagnaud, of Paris, one of the contracting firm, recommended to him by Mr. Pontzen, the writer was placed in communication with Mr. Zurcher, the Director General of the enterprise at Bern, and through him with engineers in charge of the various parts of the work, all of whom were very ready to give him full and reliable information. It is not out of place here to mention them, as without their cordial assistance this article could not have been prepared. Mr. Pettavel, in charge at Frutigen, who provided a special car to go over the service line between Frutigen and Kandersteg at the tunnel entrance; Mr. Kirchoff, who acted as guide; Mr. Chapuy, who showed at Kandersteg the very interesting installation for making sand cement, a duplicate of which is at the south end of the tunnel; Mr. Delisle, the experienced superintendent of the compressed air and electrical and other plant of the "chantiers" at the entrance of the tunnel; Mr. Ratjen, one of the tunnel engineers, who led the way into the tunnel, about three miles in the mountain; and finally Mr. Rothpletz, who has the entire charge of the work at the north end. All these men are experienced Alpine tunnel engineers.

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SOUTH PORTAL OF THE LOETSCHBERG TUNNEL, AT GOPPENSTEIN.
(The buildings seen in the picture are part of the construction plant. The labor quarters are not in the view.)

There are two principal organizations engaged on the work:—the concession company, the "Chemin de fer des Alps Bernoises," and the "Enterprise General du Chemin de fer des Alps Bernoises," the latter being the contracting firm and composed of a group of French contractors, Messrs. Allard, Chagnaud, Colseau (deceased), Couvreux, Dolfus, Duparchit and Wiriot, several of them in association having also the contract for the Montevideo Port and other important works.

The tunnel and approaches as originally contracted for were to be single-track, and the length of the tunnel was to have been 13,735 m. (about 8½ miles), but important changes have occurred. First, the Federal Government having given a subvention of 6,000,000 francs ($1,200,000), double-track construction has been provided for, and second, due to an accident to be described later, the original tangent of the tunnel has been broken and the line diverted and lengthened to 14,536 m. (9 miles), an increase of half a mile.

The location and profile of the tunnel and its approach lines, from Frutigen to Brigue, a distance of 115.47 km. (71¾ miles), are shown in Fig 2. The entire distance between Bern and Brigue is 170½ km. (106 miles). The original tangent alinement of the tunnel is shown by a heavy line.

Dr. A. Zollinger, the technical director of the concession company, has recently furnished the technical details of the project, and the data about the various structures and tunnels have been given the writer by Mr. Zurcher. A short summary follows:

The gage is standard, 1.45 m. (4 ft. 8½ ins.)

Between Frutigen and the north portal of the tunnel the distance is 20.188 kilometers (13.63 miles), of which 9.98 km. (32,762 ft.) is on tangent and 10.21 km. (33,480 ft.) is on curve. The sharpest curves are of 300 m. (984 ft.) radius, the flattest of 1,400 m. (4,593 ft.) radius; but over half of the total curved length, 49,282 ft., is of the minimum radius. The grades of the north approach range to 2.7%; nearly two-thirds of the line, however, is on maximum grades, 2.5 to 2.7%, while only one-tenth is level.

In the main tunnel, nine miles long, which, as stated, was originally laid out on a tangent the entire length, there are three curves of 1,100 m. (3,609 ft.) radius (Fig. 3) and a total length in curve of about 2,737 m. (8,979 ft.)

The grades in the tunnel from the north portal are as follows: 7,634 m. (25,046 ft.) ascending grade of 0.7%; 602 m. (1,975 ft.) of level; and 6,300 m. (20,669 ft.) of descending grade of 0.24% to 0.38%.

The south approach between the south portal of the tunnel and Brigue has a length of 25.39 km. (15½ miles), of which 13,640 m. (44,739 ft.) is on curve and 11,750 m. (38,550 ft.) on tangent. The curves range in radius from 300 m. (984 ft.) to 1,800 m. (5,905 ft.). Nearly one-third of the curvature is of minimum radius of 300 m. The

grades run from about 2.2% to 2.7%, with short levels at the four stations.

There are 13 bridges and viaducts of over 10 m. span on the north approach. There are 12 tunnels on the north approach, two of which are over one kilometer (3,280 ft.) long, their lengths being 1,534 m. (5,032 ft.) and 1,665 m. (5,462 ft.) The total length of the twelve tunnels is 4,925 m. (16,158 ft).

The south approach has 11 bridges exceeding 10 m. in span, and 21 tunnels; only one of the tunnels is over one kilometer long, 1,365 meters (4,478 ft.), located at the abrupt change in alinement (See Fig. 2). The total length in tunnel is 7,074 m. (23,208 ft.), being 27% of the entire length of the south approach.

In accordance with the conditions of the subvention of 6,000,000 francs, above referred to, the company must make the main tunnel double-track throughout and must elsewhere provide both in tunnels and in foundations of viaducts and bridges, not in rock, for a double track. Where the rock for the second track in the approach tunnels can be excavated without interfering with the train movements it will be left for the double-track work, to be done when the traffic conditions require it. Unlined tunnels are excavated to the center line. Lined tunnels are built with full roof arch, leaving a bench up to the height of the spring of the arch on the second-track side.

According to the geological predictions, where the north end of the main tunnel is 180 m. (590 ft.) below the floor of the Gastern Valley, the ravine filled with detritus finished at a depth of 100 m. (328 ft.) below the bed of the valley, and consequently the tunnel would be driven through solid rock. Unfortunately this prediction did not prove true, for on July 24, 1908, when the main heading had reached a point 2,675 m. (1.6 miles) from the portal it struck a cleft filled with sand, gravel and water. There was a sudden and violent inburst of these materials, which in a few moments filled up the tunnel for a length of 1,800 m. (5,900 ft.), burying 25 workmen and all the drills and other installations beyond any possible hope of recovery. It is estimated that about 8,000 cu. yds. of sand and gravel entered the tunnel.

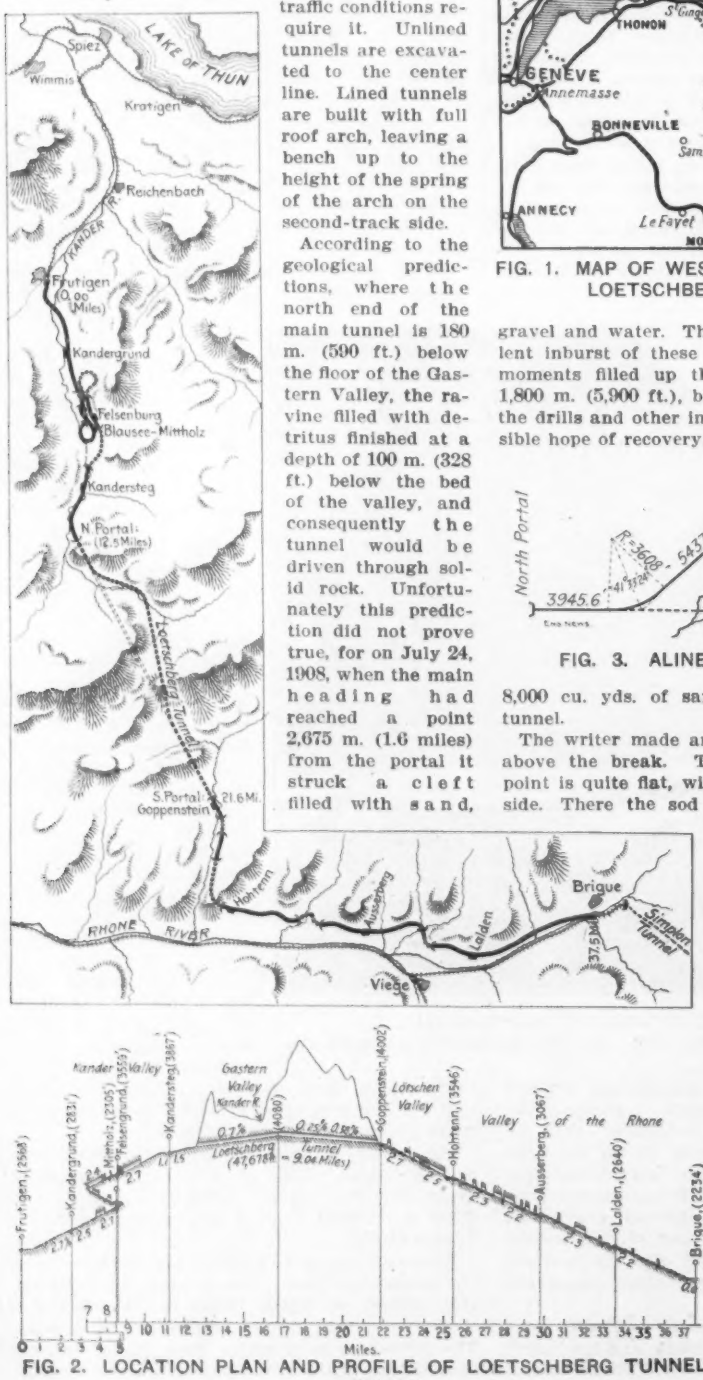


FIG. 2. LOCATION PLAN AND PROFILE OF LOETSCHBERG TUNNEL ROUTE.

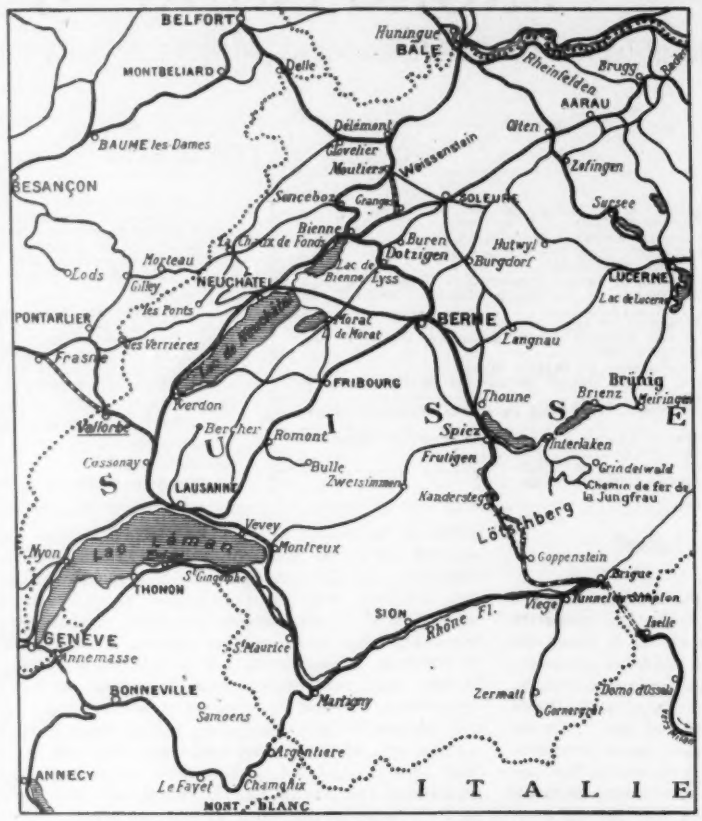


FIG. 1. MAP OF WESTERN SWITZERLAND, SHOWING RELATION OF LOETSCHBERG TUNNEL TO RAILWAY ROUTES.

The writer made an examination of the valley above the break. The Gastern Valley at this point is quite flat, with a grassy meadow on one side. There the sod is broken and crevices of some depth still appear, although the accident happened two years ago.

The geologists contended that the ancient glacial erosion in this long, flat valley could not have reached much below the lip of the solid rock at the falls several kilometers distant near the entrance of the tunnel (see Fig. 5, a photograph of the Kander Falls in the "Kius.") Borings made in the winter after the accident, to a depth of 287 m. (940 ft.) below the bed of the Gastern Valley at the break, showed nothing but detritus. The floor level of the tunnel is only 180 m. (590 ft.) below the valley. The estimated position of the bed of this detritus, drawn after the three borings were made and from them, shows that without doubt the solid rock at the deepest part of the inverted cone would still be much deeper than the borings reached.

To avoid any further possible irruption of the materials the tunnel was walled up by a 33-ft. wall at a point 1425 m. (4,675 ft.) from the portal. This wall was provided with drains for letting out any water that might accumulate behind it.

A commission of engineers was convened to decide upon the course to be adopted. Three methods were considered: First, to force the tunnel through on the original line; but this was considered impracticable, due to great pressures from the 590-ft. depth of water, sand and gravel over the tunnel. Second, to use the freezing process; but this also was considered impracticable. Third, to deviate the line and cross the Gastern Valley further up stream (see Fig. 3.) The last plan was adopted. The new line leaves the original location at a point 1.2 km. (¾ mile) from the north portal.

When the writer made his examination about the end of May last and went into the heading it was about 5 km. (3 miles) from the portal, and it was then immediately under the river.

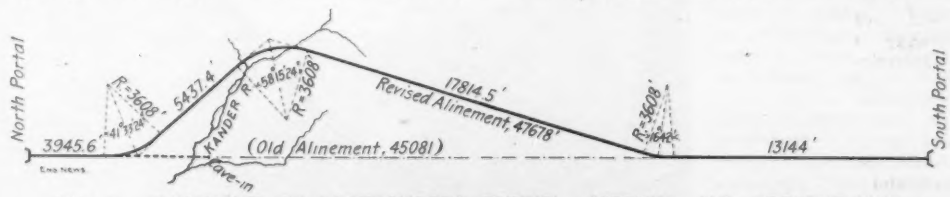


FIG. 3. ALINEMENT OF LOETSCHBERG TUNNEL, ORIGINAL AND PRESENT LINE.

As might have been expected, it was a time of considerable anxiety on the part of the engineers, who greatly desired to see themselves and those under their charge well out from under the treacherous river that had brought such disaster, and well into the granite that is found on the opposite side of the valley. A few days later they reached it and were so greatly relieved that they gave themselves a banquet. On the menu, which is a souvenir of their deliverance, is a profile showing the different kinds of rock passed through, and the massif of granite in which their future work lies. The substance of the profile is given here as Fig. 7.

The tunnel, up to the point where the granite was reached, passed through triassic limestone, carboniferous slate and dolomite, with varying slopes of the strata. As might be expected the north end of the tunnel at several points is very wet and had to be well drained and also heavily lined the entire distance. It was not an entirely comfortable place to work or visit.

The greatest thickness of rock overhead is 1,430 m. (4,692 ft.). It is estimated by Prof. Heim that the greatest rock temperature will be about 97° F. on the north side and 87° on the south side.

The tunnel is now advancing satisfactorily on both ends at an aggregate rate of about 15 m. or say 50 ft. per day. The maximum daily advance of one heading has been 12 m. which was on the north end. The two ends are expected to meet early next year. The approaches will require

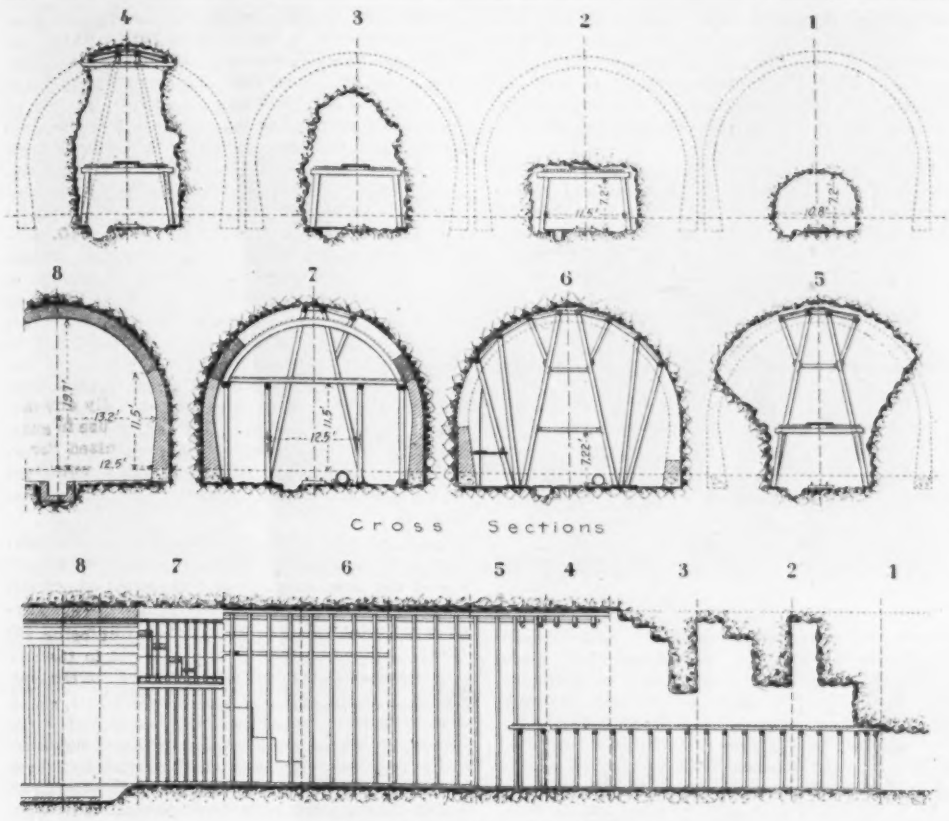


FIG. 4. SECTIONS SHOWING SUCCESSIVE STAGES OF EXCAVATION, TIMBERING AND LINING IN LOETSCHBERG TUNNEL. (TYPICAL.)

a longer time, at least all of 1912, so that the entire line may be put into operation some time in 1913.

The approaches are difficult of construction. On the north side is a helicoidal loop, largely in the interior of the mountain, with many tunnels and bridges. On the south approach the conditions for construction are still more difficult. A good highway does not exist, and the construction track cannot be kept separate from the final line, as it can be on the north side. The service line, like the final line, lies along the steep sides of the valley, and it must often be located where the permanent tunnels and other structures are to be built. The work is very difficult of access, both for the workmen and for provisions, plant and supplies.

Compressed air is used for drilling the tunnel,

Fig. 5. View of Falls of the Kander in the Klus.

Ingersoll plant on the south and Meyer (German) on the north end. The shops and plant are well arranged, ample and convenient, and the workmen are well provided for. Nothing but electric power is used. Compressed-air locomotives (Fig. 8) are used for the main tunnel. This is said to be the first time that compressed air has been used for traction purposes in tunnel work. The air pressure in the locomotive tanks is 120 kg. per sq. cm. (1,760 lbs. per sq. in.) with 20 kg. per sq. cm. (284 lbs. per sq. in.) in the cylinders.

Compressed air is supplied to the heading of the tunnel as it advances to feed the drills. Ventilation from a very complete installation follows up the work.

In accordance with the concession, electric power for all purposes is furnished to the company by the Canton of Bern from the hydraulic plants at Spiez and elsewhere. The company pays 1,000,000 francs ($200,000) for the current on each side. This comes to about 100 francs ($20) per horse power per year.

Compressed-air drills have been so greatly improved in late years that Chief Engineer Zollinger is of the opinion that now, as compared with the time of the St. Gothard construction, the same length could be drilled by half the number of machines in half the time.

The entire line from Spiez on Lake Thun to Brigue will be operated electrically. Between Frutigen and Kandersteg the trains will consist of three or four cars with a locomotive for the postal and freight trains, and two or three cars for passenger trains. When Kandersteg, the north portal, is reached and the heavy grades of the approach are passed, more units will be used through the tunnel and on the down grade to Brigue, and conversely the trains coming up from Brigue will be doubled up at Goppenstein, the south portal, for the light grades of the tunnel and the down grades to Frutigen and Spiez.

The voltage on the main line will be 15,000 and the same on the trolley line, which is arranged on overhead bridges like those used on the New Haven railway out of New York. The current is single-phase alternating of 16 cycles.

Between Spiez and Frutigen, which section of the railway was built previously, the electric equipment is already installed and experimental locomotives are now operating on the line. They were built by the Siemens-Schuckert-Oerliken Company and by the General Electric Company.

The contracting company has to furnish the fixed installation and the motors for operating the line. The power of the present locomotives is much less than required on the approaches, as the grade between Spiez and Frutigen is only 0.15% while on the approaches the grades reach 2.7%.

It is said that the motors designed for the approaches are the most powerful proposed up to this date for single-phase current. They have to be capable of hauling on a grade of 2.7% 300 tons at 40 km. (25 miles) per hour, which means 2,000 HP. capacity.

The Use of Chlorates in Commercial Explosives.

By A. L. JONES.*

Recent electrolytic processes, by which the chlorates and per-chlorates, particularly of sodium and potassium, can be made at a reduced cost, have revived interest and activity in the production of explosives from these substances. Successful chlorate explosives are now making their way in the European market, and already several promising ones are being offered in America.

Potassium chlorate, with a large store of easily yielded oxygen, has long been known as a powerful agent in producing explosives, when suitably combined with other materials, so that the oxygen may support a rapid combustion of carbon and hydrogen. The enormous energy stored up in such mixtures and the consequent volume and pressure of the gases formed, have presented a fascinating problem to inventors of all degrees of knowledge, whose works range from that of the partially informed amateur to the strictly intelligent and cautious efforts of men like Louis Berthollet and Eugene Turpin. Literature is full of records of the disasters which have overtaken some of the unfortunate dreamers of the first class and even Berthollet and Lavoisier had

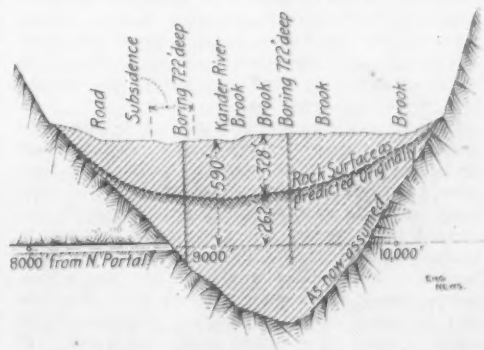


Fig. 6. Assumed and Probable Rock Profiles Under Kander Valley at Crossing of Original Alinement.

a fatal accident in 1788. Such disasters have called forth warnings from scientific men of a conservative mind, and one reads discouraging conclusions from well-informed writers that the production of a safe and practical chlorate "powder" is an impossibility from the very nature of the materials involved. An eminent authority,† writing as late as 1897, says:

> Experiments with potassium chlorate have always been disastrous; none of the many attempts to control it have been successful. Nature has made it unconquerable.

Many difficult problems have been solved by continued experiments and by a correction of the conditions that have caused the failures; but here it is not entirely a matter of patience and perseverance. An illusory success may appear in a combination of small and safe quantities of the materials, but the chance of failure may increase beyond all proportion to increase in the quantities used. The experimenter obviously is not entitled to make many mistakes. It seems

*505 South Second St., San Jose, Cal.

†M. Eissler, "Modern High Explosives," 1907 Ed., p. 138.

entirely illogical that, in spite of the precedents of modern accomplishment, in this one field human intelligence is to be baffled and that the potential energy locked up in an innocent-looking white crystal must remain useless and inert.

It might readily be supposed that some principle, formerly overlooked, might underlie the control of the quality of instability in chlorate mixtures. Such a principle has been discovered, and is applied with more or less success in the manufacture of a half dozen compounds now

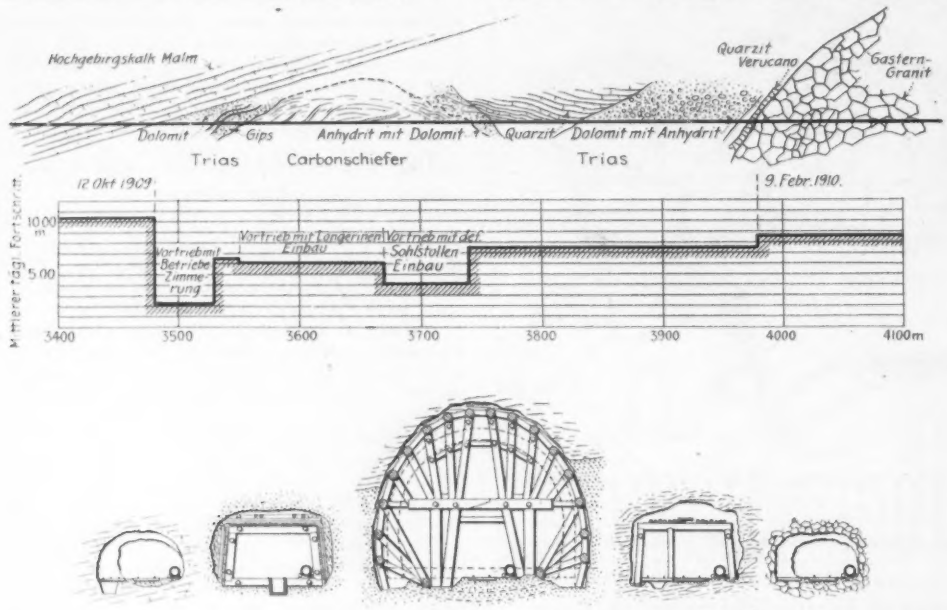


FIG. 7. TUNNEL SECTIONS UNDER GASTERN VALLEY (KANDER RIVER) ON REVISED LOCATION.

competing in the European market. Railways have made concessions in recognition of the discovery, and Government bureaus have formally admitted the possibility of securing chlorate explosives, which may be safer to handle, manufacture and transport than the conventional compounds of the gunpowder and dynamite type, while at the same time, guiltless of the treachery formerly charged against them.

Most of the chlorate mixtures that have been proposed in the past have been subject to some or all of several defects, (1) undue sensitiveness to shock, pressure and friction, (2) tendency towards spontaneous ignition, and (3) increased sensitiveness under moderate increase in temperature, so that a light glancing blow falling on a small mass would inflame the whole. Consequently, these older powders have been unsafe to manufacture, as well as dangerous while being tamped or rammed into bore holes. It has been admitted that the sensitiveness can be temporarily overcome but, after exposure and subjection to moisture, a recrystallization of the chlorate takes place on the outside of the mass, and thus the apparent safety of a freshly made powder turns out to be a delusion.

The several defects above noted are due in part to the three properties of chlorate salts; (1) low specific heat, (2) low temperature of decomposition, and (3) the absence of molecular cohesion. Chlorate of potash cannot itself be exploded under any conditions that would ever be likely to arise in practice. However, as Berthelot has shown, when a small mass is fused and brought suddenly into intense heat, a true detonation may occur. This, taken in connection with certain thermal peculiarities of the salt, is significant.

Most oxysalts evolve heat in formation, and consequently in decomposition they absorb heat, particularly when, as in the case of saltpeter (potassium nitrate) they decompose into their elements before the permanent products are formed. But the chlorates of potassium and sodium are exceptional. Thermal tables show that the quantity of heat evolved in the formation of potassium chloride is greater than the quantity absorbed in the disintegration of potassium chlorate into its elements. This salt, and also to a greater degree sodium chlorate, therefore absorbs heat in normal dissociation, but is exceptional in that it liberates heat in the primary stage of that process, a circumstance of obvious importance in the consideration of chlorate explosives.

These unique qualities do not hold for the perchlorates of ammonium, sodium and potassium, which may account for the fact that though frequently very sensitive, their control is reasonably certain. Crude and haphazard mixtures are therefore more easily affected by friction, though less sensitive to shock, than nitro-glycerine powders. Explanation is also offered by the foregoing circumstances, of the fact that inventors have frequently deceived themselves by subjecting a powder to such apparently convincing tests as the shock of heavy weight dropped great distances, shooting into sticks of powder with steel-cased rifle balls, rubbing or grinding in mills or mortars, and throwing the material into forge fires.

A consideration of physical constants alone would result in the classification of chlorate mixtures rather low in the scale of efficient high explosives. The volume of gases generated is seldom more than half that of nitro-glycerine, and the potential energy is less than two-thirds. Even though the quantity of heat generated is comparatively small, the temperature of explosion is high. This may account for the fact that hardly any materials of this class are acceptable for use in gaseous coal mines. In fact, of 21 recognized "safety" explosives (Belgium, 1907,) not one contained any chlorate. A compensating advantage is found in the simple and stable character of the gases formed, generally water and carbon dioxide. The heat evolved is, therefore, not wasted during the first stage of the explosion, in the work of disintegration of the molecules, but is utilized instantly in the dilation of the gases, and the increase of their pressure. On the other hand, the fall of pressure is rapid, not being delayed by the restitution of latent heat in the formation of the permanent products. Thus the "brisant," or breaking character, of these explosives is explained.

The late Dr. A. Dupre, chemist for Her Majesty's Inspectors of Explosives, had long been one of the most cautious and skeptical of officials regarding chlorate explosives proposed for government approval, yet he wrote in his report for 1898:

> As anticipated, the difficulties involved in the production of a safe chlorate explosive have at last been overcome, and explosives of this kind will come into use at an early date.

This, of course, does not imply that a commercially practical explosive of this type had been prepared that early, but since then some half dozen chlorate mixtures have passed the severe Home Office tests and one of these is even accepted for use in gaseous coal mines. Great stress has formerly been laid by the British Inspectors on the "broomstick test," in which a small quantity of the powder under inspection is placed on a hardwood floor and struck a glancing blow with a broom handle or a rawhide mallet. Sparking or cracking under these conditions is significant in view of the thermal qualities of chlorates, as heretofore described. This test is now applied chiefly to detect any increase in sensitiveness that may take place by subjecting the powders to varying conditions of temperature and humidity.

In general these successful chlorate explosives are the result of a proper incorporation and interpenetration of the organic and inorganic materials forming their elements. The chlorate masses must be protected from the influence of

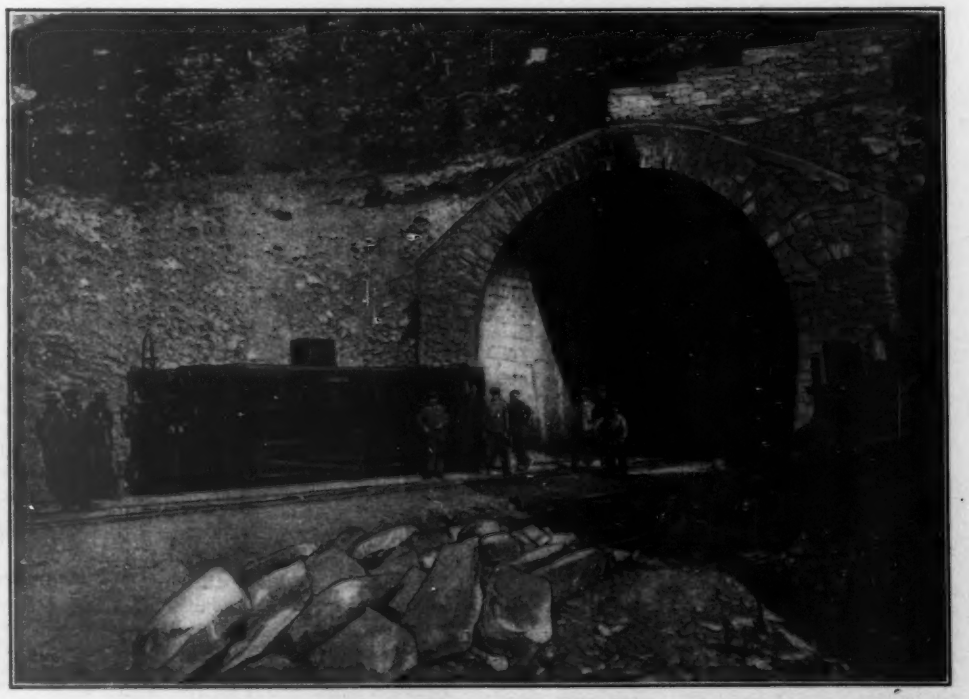


FIG. 8. COMPRESSED-AIR LOCOMOTIVE USED IN CONSTRUCTION, AT NORTH PORTAL OF LOETSCHBERG TUNNEL.

FIG. 10. MASONRY WORK AT SOUTH PORTAL.

water and moisture, which tends to dissolve out the salt and to permit it to recrystallize on the outside of the mass and thus become subject to the heating effect of shock and friction. This protection is accomplished by imbedding the chlorate particles in a matrix of an insoluble material, which is plastic or capable of yielding under shock, or by surrounding them with a closely adhering covering of such a material. If this material has the property of entering into the explosive reaction under a shock no less powerful than that given by a detonating cap, so much is gained for economy. It has also been found feasible to use nitro-derivatives of certain hydro-carbons for the combustible ingredients, in which case safety is further assured by adding suitable oils, a limit of 5 to 8% not being detrimental to the explosive qualities of the mixture. This desirable isolation of the minute chlorate particles from each other is best characterized by the French in a single word, "enrobage," and its value is briefly stated by the expression, "enrobage gives stability."

In the determination of the desirable combustible ingredients therefore, consideration must be given to the known heat-generating quality of the chlorates in one stage of decomposition. The material should possess a high carbon and hydrogen content, and yet be one whose avidity for oxygen is partially satisfied. As all the oxygen in the chlorates is available, the amount of combustible material taken should be about sufficient for complete oxidation. This will require only 20 to 30% of the entire mass, and so the physical qualities of the added substances must be considered. The explosive should also give way under pressure, or under chance blows in tamping; a hard, dry unyielding stick is evidently a source of danger through a possible transformation of mechanical into heat energy.

The use of oils in chlorate explosives is not a new idea. In 1867 F. Hahn secured a British patent for a chlorate gunpowder containing spermaceti, and since then tar, napthalene, paraffin, linseed and castor oils have been successfully used. One of the earliest of the true chlorate "powders" was made about 1897 in Chedde, Switzerland, from which it derived the name "Cheddite"; a common variety (Cheddite 60 bis.) is made up of 80 parts of potassium chlorate, 13 of mono-nitronapthalene, 2 of dinitrotoluene and 5 parts of castor oil. In England a common formula reverses the proportions of dinitrotoluene and mono-nitronapthalene..

In 1908, a safety explosive was licensed in England consisting of 74 parts of potassium chlorate, 25 of oxidized resin and one of castor oil.

A type of chlorate explosive, still little used, was devised by the celebrated Hermann Sprengel, and these are yet known as "Sprengel explosives." Powdered potassium chlorate is put into cartridges or linen bags and soaked with nitrobenzene or similar hydrocarbon just prior to use. The "rackarock" used in the famous destruction of Flood Rock, Hell Gate, New York Harbor, was of this class.

It is recorded* that a mixture of potassium chlorate and dinitrobenzole was tamped into copper cylinders which were soldered up with an alloy of low melting point, to prevent evaporation of the highly volatile hydrocarbon. Each cartridge as used contained 6 lbs. of "rackarock" and they were exploded by a heavy dynamite and fulminate detonator. Tests showed that the "rackarock" had an average explosive strength 9% greater than "No. 1 dynamite." The "No. 1 dynamite" referred to was probably the old kieselguhr dynamite now superseded.

The future success of chlorate powders will be governed by several conditions not yet entirely fulfilled. The ingredient materials must be produced at a price to justify the sale of the product at a price somewhat lower than that of standard explosives. The idea that chlorate explosives can eventually occupy the whole field, should not be entertained, for being mechanical mixtures it is evident that their modification for various uses is limited by the necessity of combining materials with reasonable regard to the proportions giving a complete combustion. At best, then, the perfect chlorate powder must find its own proper field, which, though limited, may be a large one.

Locomotives for Steep Grade Adhesion Railways.

An important consideration for railways in mountainous countries is the type of locomotive best suited to the operation of traffic on steep grades. This subject is treated in a paper read before the Institution of Civil Engineers,† and from this paper and the reported discussion we take the information presented herewith. It should be explained that the paper referred to railways which have steep grades over practically their entire length, rather than to the operation of occasional heavy grades on ordinary railways.

The paper states that although grades of 6%, or even 8%, are not unknown in special cases, a grade of 4% has been adopted very generally by engineers as the limit for smooth-rail or adhesion working. As to the relation of train load to grade, it is stated that an engine which will haul a 200-ton train (behind the tender) on a grade of 2%, will haul only 100 tons on 4% and 44 tons on 6%. On the other hand, the safe speed of descent for a given axle load on a 6% grade is only about 60% of that which is safe on a 4% grade. The capacity of the steeper line, therefore, will be hardly more than half that of the latter, and as the cost per train-mile would not be less, the freight rates would have to be higher in proportion. The rapid rise in cost of hauling with grades exceeding 4%, makes it desirable to use special devices (such as rack-rails or center grip-rails) on these heavier grades so as to admit of heavier train loads being handled. For the purpose of the paper, however, 4% was taken as the maximum grade to be considered.

Theories of the capacity of mountain railways are numerous, but they generally neglect the facts that changes of gradient, traffic requirements, etc., render speeds very variable, and that passing-places occur at irregular intervals. It is hardly necessary to point out that the speed limit is a factor of very great importance; yet its importance is often much under-estimated. On the Central Ry. of Peru, between Lima and Oroya (one of the lines with which the author is connected) gradients of 3½% and 4% are practically continuous for nearly 90 miles, yet freight trains are timed at 12½ m. p. h. between stations. This means running at 18¾ m. p. h. in places where gradients permit. Even at these speeds the arrangement of passing places, etc., with a mixed passenger and freight traffic, is very difficult, and there is little doubt that the adoption of low-speed working would considerably reduce the capacity of the line. Engines of even double the power, if worked at half the speed, would only give the same ton-mileage per day when running, and delays due to waiting at passing places would be largely increased.

Geared engines, such as the well-known Shay locomotive, have no doubt done, and are still doing, excellent work on lines with sparse traffic. But at other than very low speeds the cost of their maintenance is prohibitive. It is well worth considering, however, whether there may not be a considerable field for the use of geared engines in the future, provided that the very restricted ratio of 1:2 or 1:3 is given up, and that a system of gearing is adopted similar to the one which, in recent years, has given such excellent results with road motors.

In discussing the paper, Mr. Roman Abt (Switzerland), inventor of the Abt rack-rail system, remarked that in Europe a grade of 2.5% was considered about the maximum for adhesion working, 3% being used in some exceptional cases. With the rack-rail system, the grades may be as high as 5 or 6%, according to the carrying capacity desired. This effects a considerable saving in the cost of construction. He instanced the 6% rack-rail grades of the Transandine Ry., on which a speed of 7½ m. p. h. is attained with 60-ton engines hauling train loads of 150 tons (total weight of train 210 tons). On steep grades, high speeds are prohibitive owing to greatly increased cost of operation. Moderate speeds, on the other hand, limit the carrying capacity. As such railways are usually single track, it is important to provide ample passing-track facilities, the cost of which will be well repaid by the increase in carrying capacity.

The author of the paper does not favor the use of tank engines for service on heavy-grade lines. Owing to the large consumption of fuel and water on lines of this class the weight to be carried by tank-engines necessitates the use of special types of engines (such as the Fairlie, Meyer or Mallet) or the provision of several carrying axles. With the latter arrangement, however, it is impossible to maintain uniform loads on the driving axles, as they will be overloaded when tanks and bunkers are full or will have insufficient adhesion weight when these are empty. He claims that a tank engine having a given minimum adhesion weight and maximum axle load can be redesigned as a tender-engine (with the same fuel and water capacity) with not more than 5% increase in total weight. In his opinion, also, the tender can be braked more effectively than the carrying axles of a tank engine, and there will be less trouble with springs, axle boxes, derailments, and grinding on curves.

In the discussion on this part of the paper it was shown that duplex or articulated engines are not necessarily tank engines, but are very generally built as tender engines. To design a tender engine with an increase of only 5% in weight over a tank engine would probably result in a very light tender. Mr. Abt thought that such tenders are specially dangerous for mountain

[*See Engineering News, Sept. 12, 1885, p. 163, and Oct. 17, 1885, p. 250.—Ed.]

†"The Design of Rolling Stock for Smooth-Rail Working on Heavy Gradients," by Frederick Wm. Bach, M. Inst. C. E. Excerpt Minutes of Proceedings, Institution of Civil Engineers (London); Vol. clxxx., Session 1909-10, Part II.

roads owing to their liability to derailment. As a matter of fact, where a tender is adopted in place of tanks on the engine, the capacity is usually made considerably greater than that of the tanks, and the increase in weight is much more than 5%. Mr. George Hughes (Lancashire & Yorkshire Ry.) referred to the very extensive use of tank engines in England, and disputed the idea that they are peculiarly liable to derailments. Statistics covering a number of years fail to show any such tendency. As to the comparative weight, he considered that to redesign a tank engine as a tender engine would involve an increase in weight of 15 to 20%. Mr. R. H. Burnett (New South Wales Government Railways) also thought the 5% increase much too low. He considered that if suitable water could be obtained at sufficiently frequent intervals it would be economical to work with a tank engine. The author stated in reply, however, that he had more than once redesigned tank engines as tender engines without exceeding the 5% increase in weight.

The author has strong objections also to articulated engines, and particularly to those of the Mallet system, but these objections appear to be based in part at least upon prejudice. They are weakened by erroneous statements and estimates. He takes as an example a Mallet engine of the 0-6-6-0 class having cylinders 20 × 30 ins. and 32 × 32 ins. with 56-in. driving wheels, weighing 150 tons and having a 70-ton tender. Concerning this he remarks that:

> Supposing such an engine could be worked on a 4% grade it would haul only 430 tons gross, or a train of 210 tons behind the tender.

As a matter of fact, Mallet engines of the same class and of very similar dimensions haul train loads of 470 to 500 tons (behind the tender) on the 4% grades of the Denver, Northwestern & Pacific Ry. They have cylinders 21 × 32 ins. and 33½ × 32 ins., with 55-in. driving wheels; they weigh 147 long tons and have 70-ton tenders. One of these engines is shown in the accompanying cut and its dimensions are given in the table. The regular 2-8-0 freight engines can haul 265 tons (behind the tender) on these 4% grades, which extend for 15 miles on the west slope and 12 miles on the east slope of the mountains. The sharpest curves on these grades are nominally 16°, but actually some of them are somewhat sharper. In regular service the Mallet engines

MALLET LOCOMOTIVE (0-6-6-0 CLASS) OPERATING ON 4% GRADES ON THE DENVER, NORTHWESTERN & PACIFIC RY.

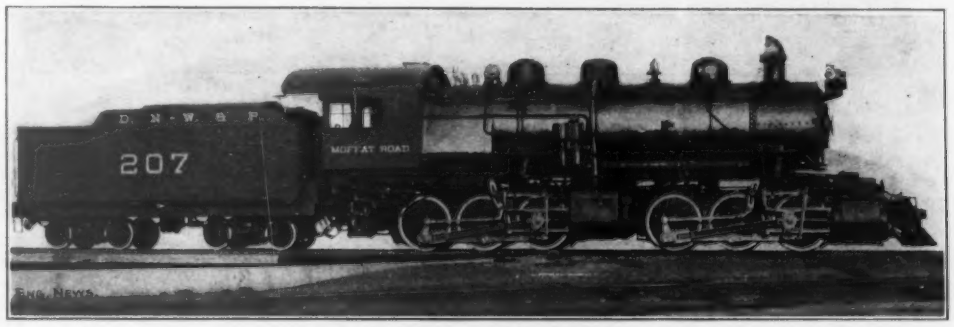
Driving wheels (12)	4 ft. 7 ins.
Wheelbase; driving (each group)	10 ft. 0 ins.
Engine	30 ft. 8 ins.
Engine and tender	64 ft. 4 ins.
Weight, engine	330,000 lbs.
Tender	160,800 lbs.
Cylinders, h. p. (2)	21 × 32 ins.
l. p. (2)	33½ × 32 ins.
Valve gear	Walschaerts
Boiler, diameter	7 ft. 0 ins.
Steam pressure	225 lbs.
Firebox	9 × 8 ft.
Tubes (409); diam, 2¼ ins.; length	21 ft. 0 ins.
Fuel	Soft coal
Heating surface; tubes	5,035.5
Firebox	203.6
Water tubes	25.3
Total	5,264.4
Grate area	72.3
Maximum tractive power	78,400 lbs.
Factor of adhesion	4.21
Water in tender	9,000 gals.
Coal in tender	12 tons

are used as helpers to trains of about 730 tons, as the 2-8-0 engines can haul these trains on other parts of the line and are capable of higher speeds than the others. We believe that some of the Mallet engines built in this country for South American railways were designed for service on long and heavy grades.

Among these are Mallet tank engines of the 0-6-6-0 class for the Colombia National Ry. (3 ft. gage). They are designed to haul train loads of 100 long tons at 12½ m.p.h. on a 4% grade (with 22° curves), the grade being compensated for curvature. These engines have cylinders 13 × 20 and 20½ × 20 ins.; driving wheels, 38 ins.; rigid wheelbase, 7 ft. 8 ins.; weight, 127,500 lbs.; factor of adhesion, 5.45; tractive effort, 23,400 lbs. working compound or 28,100 lbs. working simple.

It may be of interest to note here, for the information of our readers, that the Mallet engine has a rear group of driving axles carried in short main frames, and a forward group of driving axles carried in a swiveling steam truck whose rear end is pivoted to a cross brace between the fixed main frames. The Fairlie engine has two swiveling steam trucks, and the earlier engines had boilers of great length, each boiler having two barrels separated by a double-compartment firebox fired from the sides. Some later engines, however, have been built with two separate boilers placed end to end, with the firing deck between them. The Meyer engine is a modification of the Fairlie type. It has two swiveling steam trucks, but a single boiler of the ordinary design is used; and for this reason it has been found more economical in fuel consumption.

In the discussion, very little was said about articulated engines, but it was pointed out that their use is justified under certain conditions. Mr. S. B. Tritton reported satisfactory results with such engines of the Fairlie type, and stated that their train loads were some 12% higher than those given by the author's formulas. In place of the original double-barreled boiler of



MALLET DUPLEX COMPOUND LOCOMOTIVE OPERATING ON 4 PER CENT. GRADES; DENVER, NORTHWESTERN & PACIFIC RY.

(The hood on the smokestack is to deflect the exhaust steam and smoke when running in tunnels. It causes less accumulation of smoke in front of the cab.)

the old Fairlie design he has put two ordinary boilers back to back on a single girder frame mounted upon two steam trucks. No trouble is now experienced with the flexible connections of the steam pipes. The latest Fairlie engines weigh 120 tons, and 138-ton engines have been designed.

The author admitted that special types of engines may be desirable where the track is of light construction, the permissible axle load is low, and the steep grade is comparatively short. But where the grades are continuous and 12-ton axle loads can be applied he considered that as good or better work in proportion to the weight can be obtained from well designed engines of the 2-6-0 or 2-8-0 types, with tenders. On the Central Ry. of Peru (4 ft. 8½ ins. gage), ordinary 2-6-0 engines weighing (with tenders) 85 tons, haul 100-ton trains up 4% grades. In his opinion, with a slow-running two-cylinder engine it is impossible to use the adhesion efficiently with an early cut-off; but every ton of excess adhesion represents a considerable proportion of loss in paying load. Adhesion must be proportioned to the maximum torque, while the load is limited by the minimum torque. The provision of four cylinders on separate engines as in the Fairlie and Mallet systems does not overcome this objection.

A three-cylinder engine is advocated therefore by the author, as it can be worked, even in mountain service, with three expansions or 33% cut-off. The duplex or articulated engines mentioned would require six cylinders in order to be equally efficient. He considers that there is no doubt that for heavy freight traffic, even on ordinary grades, the three-cylinder system possesses many advantages. This is especially the case for narrow-gage lines, in view of the difficulty of designing locomotives of sufficient power. Three-cylinder engines for pushing trains up the hump grades of gravity switching yards have been adopted by the Great Central Ry. (England). In 1906, the author recommended three-cylinder engines for the 90-mile continuous 4% grade of the Central Ry. of Peru. Several of these are now under construction. They are 59-ton engines of the 2-8-0 class; cylinders, 19¾ × 24 ins.; driving wheels, 4 ft.; rigid wheelbase, 14 ft.; driving axle loads, 13 tons. Mr. Twinberrow approved of the three-cylinder plan if it did not add too much to the weight, but he thought the design would be improved by reducing the 200-lb. boiler pressure and using a superheater. In Switzerland, three-cylinder engines have been used extensively. Mr. Abt, however, considered that while they are specially advantageous on long continuous grades their advantages largely disappear where changes of grade are frequent.

Mr. David Simson disapproved of the length of rigid wheelbase in the author's engine (14 ft.), as sharp curves are usually numerous on steep-grade mountain railways. From his experience with such railways in the Andes he favored a short wheelbase, and on this account he approved of the Meyer articulated engines (7 ft. rigid wheelbase) as used on the Antofagasta and Taltal railways. To this the author replied that engines of 14-ft. rigid wheelbase on the Cerro de Pasco Ry. operated successfully over a curve of 200 ft. radius, the gage of track being widened 1 in. on the curve.

On the other hand, Mr. Tritton spoke of ten-coupled tank engines operating over very sharp curves on European railways. No provision was made for articulation or for ball-joints on the coupling rods. All that was done was to give excessive clearance (about 1 3-16 ins.) in the boxes of the leading, middle and trailing axles, so the whole wheelbase would accommodate a versed sine of fully 2 ins. Very long pins were used with the same clearance. It might seem that with full force exerted on the coupling-rod bushes the bush would fail to slide transversely on the pin. In point of fact it does slide easily, and there is no trouble with the crank pins or with the cutting of tires and brasses. His explanation was that while the bush might refuse to slide if forced directly along the pin, it slides easily under the influence of the spiral motion formed by the rotation of the bush around the pin and the lateral movement of the pin in the bush.

Control of Trains on Steep Grades.

One special subject discussed in connection with this paper was the control of trains in descending long steep grades. In view of the varying weight of freight cars, the author prefers good hand brakes to power brakes on freight trains. Some extracts from his remarks are given below:

> It would be superfluous to insist upon the necessity for sound brake design for service on steep gradients, yet this is a matter often neglected by designers of locomotives. The result is that very few locomotives can move about safely by themselves on gradients as steep as 4%, but require cars to be coupled to them to assist in braking, which is a dangerous condition for both.
>
> The change of pressure in vacuum brakes at varying altitudes makes them difficult of efficient application on mountain railways. The use of compressed air for both train and engine meets with a difficulty at the outset, inasmuch as, with anything like efficient pressure on the engine brake shoes, the tires of the car wheels are practically certain to be overheated, even at very low speeds.
>
> With loads of 10 to 12 tons per axle it is not possible to brake safely on 4% gradients at a speed of more than 10 m. p. h. At the same time, it is highly necessary for emergency purposes that the engine should be well braked, and by far the best arrangement is to have an

entirely separate steam-brake (with ample leverage) for both engine and tender. A water-brake in the cylinders should not be omitted, and the tender hand-brake should enable 70% of the total weight of the tender (at the time of application) to be put on the brakeshoes, no matter how it may be loaded. Brake-gear should be fully compensated.

A brakeshoe in continuous use over extended periods will not absorb more than 10 HP., and even at this it will severely heat the wheel with which it is in contact. For this reason it is imperative that the engine-tires should be well fixed, say with 1¼-in. fine-threaded steel screws between the spokes. Tires should never be run under 2 ins. in thickness.

As to passenger cars, for continuous braking on these gradients chilled wheels are much superior to steel-tired wheels. The weight of a passenger car on the rails is sufficiently uniform to permit the use of air-brakes with advantage and safety.

Where zigzags occur with frequency, and changes of gradient are numerous, there is some trouble in working smoothly with ordinary automatic brakes, and the "straight air" system in combination with automatic brakes is sometimes used. Such conditions obtain on the Oroya Ry., and the passenger equipment on that line has been fitted with a brake which works as an ordinary automatic brake in emergency applications, but has a double train-pipe enabling the exhaust from the brake-cylinders to be controlled through a special driver's valve on the engine. By this means the power of the brake can be varied without trouble, and the necessity for taking off the brake before making new applications does not exist. This arrangement has not previously been applied except to electric railways. It was designed by the Westinghouse Brake Co., and its working is eminently satisfactory for passenger-stock.

In spite of all the care that may be exercised in using the maximum number of wheels on freight cars for down-gradient service, severe heating is sure to occur, and on one of the lines under the supervision of the author troubles with lubrication are so serious that axle-boxes need revision after every round trip. For this reason journals should be amply large, the pressure not exceeding, say, 800 lbs. per inch of length. The capacity of axle-boxes should be small, or with frequent packing much loss will result.

Where wheels with tires are adopted it would be advantageous to use them of large dimensions, to assist in radiation. This would apply equally to cast chilled wheels, were it not for the fact that with increase of diameter, the weight and risk of failure increase rapidly; for this type, therefore, the American standard diameter of 33 ins. is very suitable.

The pressure on brake-blocks should never be less than 40% of the load on the rail, and should not exceed 70% for low speeds. With cars weighing only 6½ tons empty and 26½ tons full, this condition is not possible of attainment, except by the use of variable brake-power. Mountain trains are composed of a very few units and these often vary considerably in weight per axle; "cutting out" therefore cannot be resorted to, and the greatest nicety of adjustment is necessary, in order to avoid excessive heating and skidding of wheels on the one hand, and dangerous lack of brake-power on the other. For these reasons, for freight cars on heavy gradients, really good hand-brakes are to be preferred to any system of power-brakes. On lines having considerable traffic any delay to a train necessitates its protection by flags or lights, and it is advisable to have at least three men (and preferably four) for such service. These men can do the braking perfectly well. The cars can be fitted with brakes worked from either end, and one man can thus handle two cars. Even with hand brakes it is advisable to have variable brake-power on cars in which the ratio of tare to total weight is less than 1:3.

In the discussion, Mr. Simson agreed that a steam brake was necessary, but stated that it could be used only as an emergency brake. He has found that if the engine brake was used continuously, the tires were so heated that they became loose. On the Antofagasta Ry., therefore, the practice was to control the train with the Westinghouse train brakes, using the engine brake only in an emergency. Mr. H. K. Bamber stated that in India, brakeshoes were applied on both sides of the wheels to prevent undue pressure on one side of the journal, which would result in heating and in loss of alinement of the axle. The loosening of tires due to their heating from the action of the brake-shoe was a serious difficulty. Mr. Twinberrow considered that the engine should be designed to work a counterpressure brake (presumably with air or steam in the cylinders) so that it could control any load which it could haul up the grade without putting the brakeshoes in action. He proposed to apply the brakeshoes, therefore, to a brake drum on the axle (instead of to the wheel tires), so as to be available in case of emergency. We may note that the use of air or steam in the cylinders for braking on steep grades, as employed in the Lechatellier back-pressure brake-system, has been in use in Europe for nearly 50 years. It is used on many adhesion railways and almost universally on rack-railways. In this country it is used on the rack-rail locomotives of the Pikes Peak Ry. (Engineering News, April 6, 1899).

Mr. Abt stated that when the Harz Ry. was opened (25 years ago) instructions were given that on all down grades locomotives equipped with air-brakes for adhesion and rack gear must alone undertake the regulation of the speed. After a year of satisfactory working it was recognized that the combined brake power of the engine and the cars must control the train. On mountain railways, however, it is of great importance that the locomotive should provide the most powerful means of braking. In his own practice, for such railways, he requires that the locomotive shall be able to regulate the speed of the whole train on the steep grades. While excellent results have been attained with vacuum brakes on a number of mountain railways, he considered the Westinghouse brake preferable on a railway rising from sea level to a height of several thousand feet.

Several engineers disagreed with the author's approval of chilled cast-iron wheels on the ground of safety for braking purposes. Mr. Josiah Harding had used steel-tired wheels and cast-steel wheels (without separate tires) on the Junin Ry., in Chile. He agreed, however, that a certain proportion of the braking should be done by hand. In fact, in some cases it would pay to do it all in this way; there would be a considerable saving in weight, while the brakemen could relieve any car that might show indications of a hot-box. He had had promising results with roller bearings.

Mr. Robert Stirling disapproved of the chilled cast-iron wheels, and on the Tocopilla Ry. (Chile) he had found very little trouble from the loosening of steel tires under the influence of the braking action. Solid disk wheels of cast-iron and of steel gave trouble from the heat (due to braking) being conducted to the journals more rapidly than in wheels having spokes, while the cast-iron wheels were liable to crack in cooling. His double-truck freight cars now have wrought-iron spoke centers, with steel tires 2½ ins. thick and 29 ins. diameter. This railway has one stretch of 17 miles with practically continuous 4% grades and almost continuous curves, many of the curves being of 180 ft. radius. The locomotive and cars are equipped with the automatic vacuum brake, but a valve on the locomotive keeps the driving-wheel brakes normally out of action. The braking is done entirely on the wheels of the loaded cars, but in emergency the brakes can be applied instantly on the engine. The cars of descending trains have an average load of 6 tons per axle. This practice avoids the excessive heating of the driving-wheel tires which would result from a 17-mile run on a 4% grade.

The argument against chilled cast-iron wheels was supported also by Mr. Cecil Watson, who explained that such wheels had been abandoned by the Darjeeling-Himalaya Ry. (India) in favor of special steel wheels which were found to be more satisfactory under conditions of continuous braking. The Kalka-Simla Ry. (India) also uses cast-steel wheels. Both of these railways (24 ins. and 30 ins. gage respectively) has adopted the practice of having one loose wheel on each axle, on account of the numerous and sharp curves. Mr. Watson agreed with the author that on mountain railways hand-brakes were preferable to the power brakes for the freight cars.

In reply to all these arguments against the chilled cast-iron wheel, however, the author intimated that the factors of speed and axle load had not been considered by those who advocated steel tired wheels. In his opinion:

> For working down-hill for several hours continuously on 4% grade at 15½ m. p. h., and with axle loads of 7 or 8 tons, the heating of steel tires would be fatal. For such work, light cast-iron wheels, chilled only ¾-in. deep, would be found the safest and most economical.

Concrete Protection Coating for a Small Tank Tower.

A 60-ft. tower supporting an elevated tank in the residence colony of the Highland Summer Club, at White Bluff, Tenn., was recently protected with a concrete casing of the posts and struts because of rather rapid rusting. The half-tone view herewith shows the result. The work proved simple and remarkably cheap.

The tank and tower were built in 1902. Rusting went on, in spite of frequent cleaning and painting, until in the fall of 1910 strengthening or other treatment was required. The tower was still strong enough for safety, but it was evident that some means of checking the progress of deterioration and rusting up the lost strength was desirable. The four tower legs were composed each of four 3½ × 3½ × ¼-in. angles, riveted in star shape, and the struts of two angles of the same size, riveted back to back. The legs were not much rusted, but the struts had suffered badly, as the stitch riveting was widely spaced and the water entering the joint

A 60-ft. Tank-Tower at White Bluff, Tenn., Whose Posts and Struts Were Cased in Concrete When Rust Troubles Became Serious.

caused the angles to be forced apart by the rust. Mr. Hunter McDonald, Chief Engineer of the Nashville, Chattanooga & St. Louis Ry. and President of the Club, had to decide upon the most suitable way of dealing with the case. He concluded that the cheapest and best method was to encase all of the tower except the diagonal bracing with concrete. This was carried out.

The columns were wrapped spirally with No. 9 steel wire on a pitch of 3 ins. The struts were similarly wrapped, and, in addition, two ¼-in. rods were placed horizontally under each strut. The forms for the columns were built up in heights of 4 ft., and it was found that this permitted thorough filling and ramming of the concrete. As may be seen from the photograph, the junction of strut and post concrete was well filleted. Small diagonal corner angles in the horizontal plane between adjoining struts were also encased in concrete. The diagonal rods are not specially bonded where they pass out of the concrete filleting between post and strut.

The concrete covering has outside dimensions of 10 × 10 ins. for the posts and 6 × 8 ins. for the struts.

The total work cost $200, which is equivalent to about $10 per cu. yd. of concrete in place.

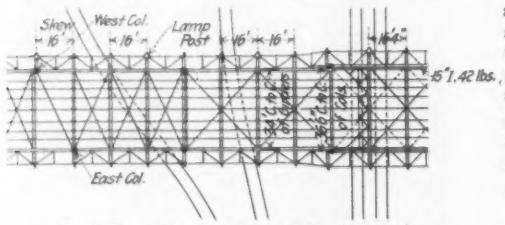
New Street Viaducts at Denver, Colo.

The city of Denver, Colo., lies mainly on the east side of the valley of the South Platte River, which makes a curved sweep through the city, the chord line of the curve lying approximately north and south. Practically all the railway lines enter the city along the bottom of this valley, and here are located the freight yards, freight houses, and numerous manufacturing plants. Several of the principal streets are carried across the valley by long steel viaducts, and the number of these structures must be increased with the development of the western part of the city.

The 20th St. Viaduct.

One of the latest of the viaducts is that on the line of 20th St., which was built in 1909-10. It starts at Blake St. and runs northwest to a point near the junction of Osage St. and 33d Ave., a distance of about 4,400 ft. Near the western end is a curve of 6° 48', with an enclosed angle of 12° 58', having a length of 190.34 ft. on the center line (841 ft. radius). It is mainly a plate-girder structure, having both deck and through spans, the span lengths being principally 16 ft., 32 ft., 48 ft., 64 ft., and 80 ft. There are also eight through-truss spans of 98 ft., 106 ft., 111.3 (2), 144 ft. (2), 150 ft. (5) and 165.3 ft. There is no symmetrical grouping of the spans, the varying arrangement being governed by the necessity of placing the supporting columns so as not to interfere with the numerous tracks, buildings, and streets crossed by the viaduct. The average height is 28 ft. from the foundation pedestals to the roadway level. The use of deck or through girders also is governed by the headway required. In a number of spans the bents are skewed to the line of the viaduct, this being made necessary by the angle at which several of the railway tracks cross the line of the viaduct.

Beginning at Blake St. there is a fill with concrete retaining walls for a length of 108 ft., followed by a few girder spans (including a cantilever span of 32 ft.), and then by four truss spans over the Union Pacific Ry. tracks. The first of these spans is separated from the others by a 42-ft. through girder span which just clears the roof



Part Plan Showing Lateral Bracing.

of a freight house, the supporting bents being built into the walls of the building. A second group of tracks is crossed by 60-ft. and 80-ft. deck spans and a 98-ft. through truss span, while a third group is crossed by a pair of truss spans of 111.3 ft. The last truss span (98 ft.) is over the main channel of the South Platte River. The west end has a group of 16-ft. spans, the alternate spans having longitudinal horizontal struts and diagonal bracing to form towers. Beyond this is a short fill. The partial elevation in Fig. 1 illustrates the general character of the structure.

The main structure has a 34-ft. roadway and two 6-ft. sidewalks carried by cantilever brackets. Along Delgany St. there is a lateral approach 650 ft. long, with girder spans of 16 ft., 32 ft. and 48 ft. This has a 24-ft. roadway and no sidewalks. The grade of the main viaduct from Blake St. is an ascent of 4.5% for about 200 ft. to attain the necessary headway; beyond this is a descending grade of 0.545%, followed by an ascending grade of 0.1% which extends over the greater part of the viaduct. The Delgany St. approach has a grade of 5%.

The live load for which the viaduct was designed is as follows: Roadway, 100 lbs. per sq. ft., and a moving load consisting of one 18-ton steam roller; sidewalk, 100 lbs. per sq. ft. This viaduct carries no street railway tracks.

The viaduct was built by (and at the expense of) the railways crossed: The Union Pacific Ry., the Colorado & Southern Ry.; the Chicago, Burlington & Quincy Ry., and the Denver, Northwestern & Pacific Ry. The plans were prepared by Mr. H. S. Crocker, M. Am. Soc. C. E. (of the firm of Crocker & Ketchum, Denver), as Consulting Engineer for the railways; they were subject to the approval of the engineers of the companies and of the city's Board of Public Works. The contract for the foundation work was let to the A. M. Blodgett Construction Co., of Kansas City, Mo. The contract for the superstructure and its erection was let to the Milwaukee Bridge Co., of Milwaukee, Wis. Work on the foundations was commenced in April, 1909. The erection of the superstructure, was commenced in August, 1909, and by June, 1910, about half of the steel work had been erected.

SUBSTRUCTURE.—For the greater part of the structure the foundations are concrete pedestals (194 in all) for steel bents. There is one high masonry pier supporting the ends of two trusses, while two low piers carry the steel bents for the truss span over the river. Three abutments are required for the ends of the main viaduct and its Delgany St. lateral approach. The abutments are of gravity section, without reinforcement, and have a batter of ¾-in. to 1 ft. on the face and 2¾ ins. to 1 ft. on the back; the top width (with 4 ins. projection over the face) is 2 ft. At the west end, the viaduct is at an angle with the street lines, and one wing wall of the abutment has seats for the skew floor beams of the end spans. These walls have expansion joints at intervals of 32 ft. to 48 ft. The two piers of the channel span are 46.6 × 11.6 ft. over the base, which is about 11 ft. below the surface; the pier proper extends 10 ft. 6 ins. above the surface, and above this its ends are carried up about 11.75 ft. as pedestals (to a total height of 32 ft. above the base). These pedestals have 15-in. caps, 9 ft. 1 in. × 8 ft. 4 ins., reinforced at top and bottom by ¾-in. corrugated bars, and upon these are the seats for the columns of the bent. The face batter is ½-in. per ft. and the top of the pier proper is finished to a triangular section between the pedestals.

The pedestals for the bents of the viaduct are of the usual pyramidal form, mainly 42 ins. sq. on top, except where a larger size (46 ins. to 54 ins.) is required for heavy columns supporting long spans. The face batter is 2½ ins. per ft., and each pedestal has two foundation courses 12 to 15 ins. thick. In each pedestal are set two 1¼-in. anchor bolts (four in the large pedestals) about 18 ins. long. Two very heavy pedestals on the bank of the river carry the bent for the girder span adjacent to the channel truss span, and are placed eccentrically to the line of the viaduct. One of these has a base 16 × 8½ ft., 6 ft. deep, on 15 piles, and then the pedestal proper tapering from 13 × 7½ ft. to 5 × 5 ft. in a height of 16 ft. The other is built directly over a sewer, which it straddles. This is of reinforced-concrete and its design is shown in Fig. 2.

The foundations are carried down to a bed of gravel or shale, and are designed to give an average loading not to exceed 2 tons per sq. ft. on the base. Foundation piles and steel reinforcement are used only in a few cases. The concrete is composed of Portland cement (supplied by the railway companies), sand and gravel. The sand was allowed to contain not over 5% of clay or loam. The gravel was specified to be composed of pebbles not over 2 ins. in size, and to be free from clay; if it contained any considerable quantity of sand the proportion was to be determined accurately so as to maintain the proper proportion of sand in the concrete. The steel reinforcement consists of Johnson corrugated steel bars, of

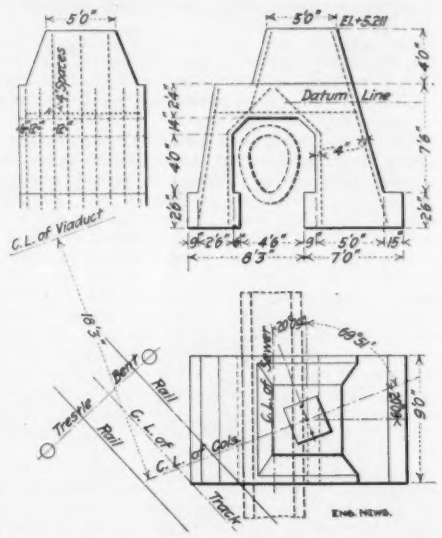


Fig. 2. Foundation for Viaduct Column Placed Over a Sewer.

a grade conforming to the "Manufacturers" specifications for steel. The facing was made simply by working the coarse material back from the face, but the specifications allowed a 1-in. mortar facing in the forms as an alternative method. The tops of pedestals, bridge seats, wingwalls, copings, etc., were finished with a ½-in. to 1-in. layer of 1:1 mortar, laid with the top course of cement.

The concrete proportions are as follows: 1:3:6 for pedestals, footing courses, and walls of abutments and piers below ground; 1:3:5 for walls and abutments above ground; 1:2:4 for bridge seats and copings. No salt was allowed for reinforced-concrete laid in freezing weather. In depositing concrete, it was not allowed to be dropped for a height of over 6 ft., troughs being used and kept full, so as to avoid disintegration of the mass in sliding down.

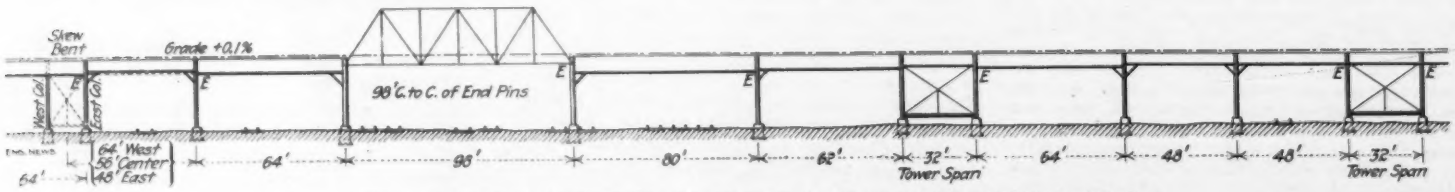


FIG. 1. PARTIAL ELEVATION OF THE 20TH ST. VIADUCT; DENVER, COLO

SUPERSTRUCTURE.—Typical cross sections of the deck and through girder spans are shown in Fig. 3. The columns and girders (and trusses) are 36 ft. 6 ins. c. to c.; they carry plate girder floor beams spaced and with lateral bracing arranged as shown on the plan, Fig. 1.

The columns of the viaduct bents are mainly 10-in. or 14-in. H-beams (Bethlehem section). The columns of bents supporting trusses and some of the long girder spans are built-up H-sections, with side plates, diaphragm plate, inside connection angles and outside flange angles connected by lacing bars (parallel with the diaphragm). These special columns are from 20¼ × 15 ins. to 33¼ × 17½ ins. Each bent has at the top a cross girder riveted between the columns. The steel bents carrying the 98-ft. truss have H-section columns with 20-in. side plates and a 15-in. I-beam diaphragm. Between these columns is a transverse truss or cross girder on which are three built-up pedestals to support a 24-in. plate

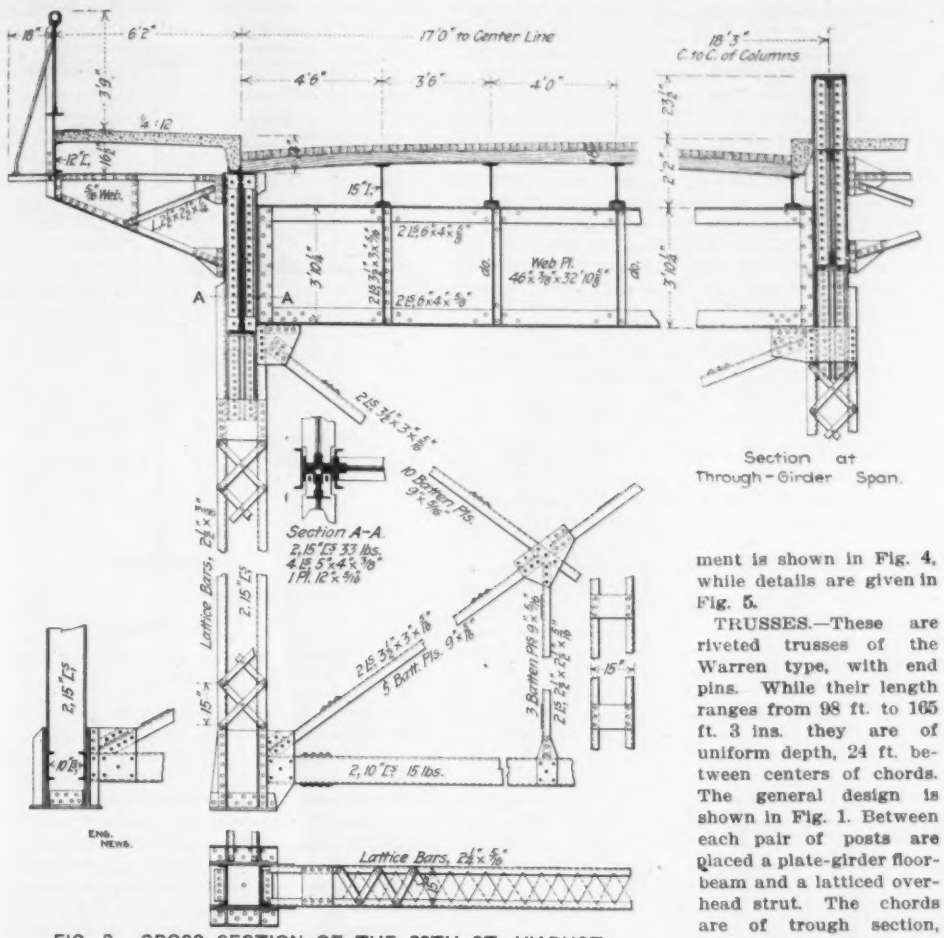


FIG. 3. CROSS SECTION OF THE 20TH ST. VIADUCT; DENVER, COLO.

girder to which are attached the stringers of the adjacent girder span.

Most of the spans have deck girders which are riveted between the columns. A number of them, however, have through girders in order to give the required headway without raising the grade. These also are riveted between the columns, which extend up to the top of the girders. These girders have shelf angles to carry the sidewalk slab on one side and the curb on the other.

The floor-beams are mainly 46-in. plate girders, riveted between connection angles on the webs of the main girders. Upon the floor-beams of the deck girders and the cross girders of the bents are lines of 15-in. and 12-in. I-beam stringers blocked up to conform to the contour of the roadway. On the through girder spans, the stringers are carried by connection angles riveted to the webs of the floor-beams and the stringers. The I-beams are connected by transverse angles. The sidewalk cantilever brackets are built up of angles, and on the outer end is a 12-in. channel which supports the sidewalk slab and forms an attachment for the hand rail posts.

32-FT. CANTILEVER SPAN.—This rather curious design was made to meet a combination of conditions which required (1) a span of this length to accommodate the railway tracks beneath, (2) a shallow floor to give all the headway possible over these tracks below, and (3) a low position for the roadway, so as to avoid increasing the approach grade of 4.5%. The flanking spans are a 29½-ft. deck girder (48 ins. deep) carrying the end of the grade, and a 16½-ft. deck girder (30½ ins. deep) on the easier grade. To these girders are riveted 8-ft. cantilever brackets, and across the end of each cantilever arm is a 20-in. built-up beam to which the floor stringers are riveted. Between angle connections on the webs of these two beams are riveted the ends of 15-in. I-beams 16 ft. long, forming the suspended span; these are in line with the girders and stringers. The sidewalks are carried in the same manner as on the regular spans. The general arrangement is shown in Fig. 4, while details are given in Fig. 5.

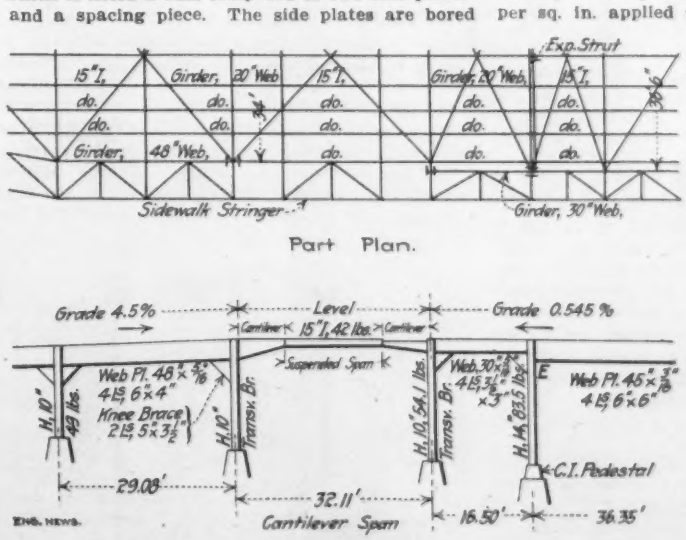


FIG. 4. 32-FT. CANTILEVER SPAN IN THE 20TH ST. VIADUCT.

TRUSSES.—These are riveted trusses of the Warren type, with end pins. While their length ranges from 98 ft. to 165 ft. 3 ins. they are of uniform depth, 24 ft. between centers of chords. The general design is shown in Fig. 1. Between each pair of posts are placed a plate-girder floor-beam and a latticed overhead strut. The chords are of trough section, with two side plates, four outside flange angles and top and bottom lacing. In the end post and top chord, however, a top cover plate is used instead of lacing.

The trusses being carried by steel bents (except for one concrete pier), there was no room for the usual end shoes and bearings. The fixed end of each truss is carried by a pin passing through the chord and the side plates of the column. The expansion end has a similar pin to which is fitted a link composed of two side plates and a spacing piece. The side plates are bored at top and bottom, the top being supported by a pin which bears in holes in the webs of the column, while the lower end supports the truss by a pin which passes through the link and the end post. This arrangement, which is shown in Fig. 6, allows for the free movement of the truss in contraction and expansion. On one of the spans, however, the arrangement is reversed, the truss pin being above and the supporting pin in the column placed beneath, so that the link becomes a rocker instead of a hanger.

On the masonry pier mentioned above there are ordinary fixed bearings for the end of one span, and a roller expansion bearing (with circular 5-in. rollers) for the end of the other span. At some of the expansion bearings, the ends of the adjacent girders were reduced in depth in order to connect them to the columns above the pins for the truss supports.

HAND RAILING AND POSTS.—The hand railing, Fig. 7, consists of a lattice of notched bars riveted to top and bottom angles, and this is supported at intervals of about 16 ft. by posts of 3 × 2½-in. angles which are riveted to the 12-in. channels on the sidewalk brackets. The top rail consists of a 3-in. channel riveted to the angles of the lattice work. The railing is supported at panel points by 1-in. brace rods attached to plates on the tops of the columns, or to the extended top angle of the sidewalk bracket. On the Delgany St. lateral viaduct (with no sidewalks), the posts are spaced 8 ft. apart on the superstructure and 10 ft. on the retaining walls of the approach. There are cast-iron lamp posts about 50 ft. apart along one side of the viaduct and lateral approach. These are shown in Fig. 8, and their design was approved by the electric light company and the Denver Art Commission.

PAVING.—Upon the I-beam stringers is laid a continuous subfloor of transverse 5-in. planks 8, 10 and 12 ins. wide, and upon this is the pavement of rectangular blocks 3 ins. thick, 4 ins. wide and 5 to 10 ins. long. The planks and blocks are of creosoted yellow pine, treated with 12 lbs. of creosote per cu. ft. for the former and 16 lbs. for the latter. On the Delgany St. lateral approach (with no sidewalks), 12 × 12-in. guard timbers are laid on each side; the upper corner of each is faced with an angle 3 × 3 ins., secured by ¾ × 4-in. lag screws in the top and ⅝-in. through bolts in the side, all spaced 30 ins. apart.

The specifications for the treatment of the planks and paving blocks may be summarized as follows; the timber on being placed in the retort is to be subjected to a temperature increasing gradually to 225 or 260° F.; this is maintained for four hours and then lowered to 240°. The air is then exhausted to a mercury vacuum of 24 ins., which is maintained during the admission of the creosote oil, which is heated to 200° F. When the timber is submerged, the vacuum is discontinued and hydraulic pressure of not less than 100 lbs. per sq. in. applied gradually, the timber being kept submerged until the required amount of oil has been injected. The oil is to come from works making bituminous-coal gas (not water gas), and must contain about 5% of tar acids (2% minimum) and 15 to 20% of naphthaline. It must be liquid at 100° F., no deposit taking place above 93°. When distilled at 600° there must remain at least 25% of residue. Specific gravity, at least 1.10 at 68° F.

The sidewalk is a 4-in. slab of concrete, having a fall of ¼-in. per ft. towards the curb, and is reinforced by transverse steel bars 2 ins. from the bottom. This is made with a 1:2:4 mixture, and given a granolithic top finish. On the deck girder spans, the curb is formed as a part of the sidewalk slab, its lower edge resting in a channel riveted to the top of the girder. On the through girder spans the curb is separated from the sidewalk by the girder web, in which drainage openings are formed. Here the curb rests on a shelf angle on the girder web and a channel riveted to

the top of the girder. On the through girder spans the curb is separated from the sidewalk by the girder web, in which drainage openings are formed. Here the curb rests on a shelf angle on the girder web and a channel riveted to the top of the side stringer of the roadway (Fig. 3), while the sidewalk slab rests on a similar shelf angle. The concrete on each side is rounded up against the web of the girder.

STRUCTURAL STEEL.—The material used in the viaduct was acid open-hearth steel, specified to contain not more than 0.08% phosphorus and 0.05% sulphur. All material was medium steel of quality as follows, the elastic limit in each case being 50% of the ultimate strength:

	Ult. strength, lbs. per sq. in.	Elongation (in 8 ins.)
Plates and shapes.....	58,000 to 66,000	25%
Pins, rollers and plates and bars bearing on rollers....	62,000 to 70,000	22%
Rivets (soft or rivet steel).	50,000 to 58,000	28%

Holes for shop and field rivets were required to be punched to 1/16-in. greater diameter than the nominal diameter of the rivets, except that for ⅞-in. rivets in the trusses the field holes were to be punched to 13/16-in. and reamed to 15/16-in.

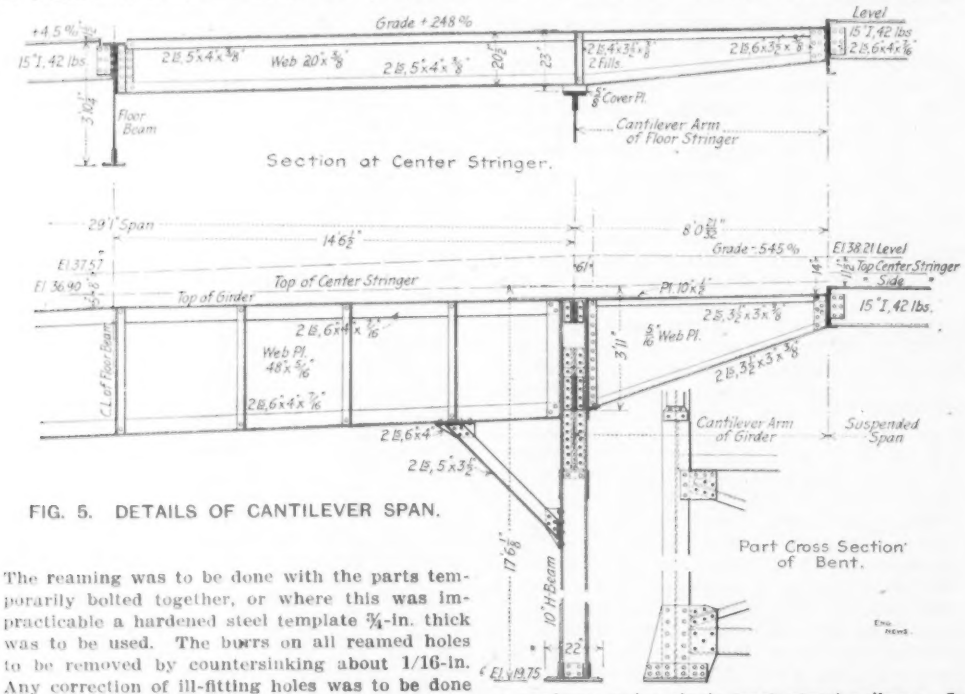


FIG. 5. DETAILS OF CANTILEVER SPAN.

The reaming was to be done with the parts temporarily bolted together, or where this was impracticable a hardened steel template ¾-in. thick was to be used. The burrs on all reamed holes to be removed by countersinking about 1/16-in. Any correction of ill-fitting holes was to be done by reaming, no drifting being allowed. Rivets were to be machine driven where possible, and for those with more than 1-in. grip a machine was to be used exerting a direct pressure upon the rivet (irrespective of the thickness of the pieces being riveted).

ERECTION.—The erection was done mainly by a traveling stiff-leg 25-ton derrick having an 80-ft. boom. This machine traveled on rollers on the finished part of the girder spans or on the falsework erected for the truss spans. The material was stored on the ground at convenient points along the line of the viaduct, being delivered to the traveler on trucks and hoisted up to the structure by the traveler. The specifications for the erection included the following clauses as to "correction of misfits and shop errors."

The contractor will be required to correct any "ordinary misfits" without extra charge.

The phrase "ordinary misfits" means: slight variations in location of field holes, requiring drifting and some reaming; tight fits or slight overrun of material, requiring a little chipping; coping of isolated beams; drilling a few blind holes, and the occasional rehandling of members on account of errors in assembling marks.

Misfits and shop errors of any considerable magnitude shall be immediately reported to the engineer, for his inspection prior to their correction, and the contractor shall keep an itemized account of the cost of such corrections, presenting to the engineer for his approval a certified copy of the same together with a clear description of the work done, including in the same (1) piece marks of members concerned, (2) numbers of drawings which may be referred to in studying said description, and (3) a statement indicating full comparison between the drawings of the requirements of the structure and the members fabricated.

The foregoing description and statement shall indicate the character and amount of the error, and whether it originated in drawings or fabrication. It is intended to be used by the engineer as the basis for a charge against the manufacturing company on account of misfits and shop errors. And it is understood that the bill to be rendered for the same shall not include profit, nor shall its amount be in excess of what the engineer shall consider reasonable under the circumstances.

PAINTING.—In view of the fact that the viaduct is exposed continually to smoke and gases from the locomotives, the protection of the steel work against corrosion was specially necessary, particularly as the floor provides no protection but rather serves to confine or pocket the gases. The structural material was given a coat of "carbonizing coating" at the shops, and all field rivets were painted as soon as driven and inspected After the erection was completed, the structure was given two coats of the same material, the second coat (black) not less than ten days after the first. Contact surfaces and parts inaccessible after riveting were given a coat of "oxidized carbon cement" in semi-paste form. These requirements applied also to the hand-railing.

The 23d St. Viaduct Reconstruction.

Another piece of viaduct work done in Denver recently, was the reconstruction of the south portion of the 23d St. viaduct, which had originally a roadway and a single track street railway. In order to bring a new interurban railway into the city over the lines of the Denver City Tramway Co., the city (by request of the company, and at the latter's expense) rebuilt the structure for a double track standard-gage line with heavy cars. The live load was as follows: for the railway tracks, two 100-ton cars on each track, simultaneously; for the roadway and sidewalk, 100 lbs. per sq. ft.

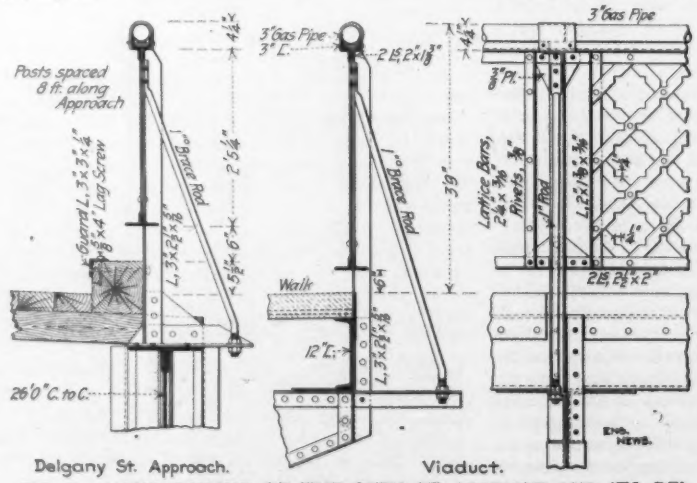


FIG. 7. HAND RAILING OF THE 20TH ST. VIADUCT AND ITS DELGANY ST. APPROACH; DENVER, COLO.

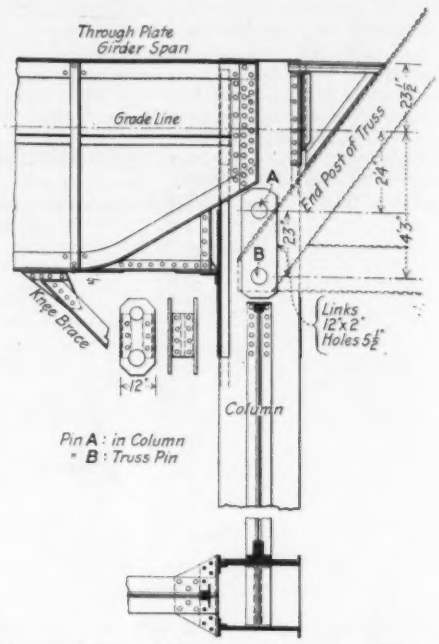


Fig. 6. Hanger Support for Expansion End of Truss Span.

The work included (1) four 136½-ft. through truss spans to replace two iron spans and a timber trestle; (2) about 400 ft. of deck plate-girder viaduct to replace the old timber trestles (having 20-ft. spans). The clear headway was about 22 ft. for the old structure; for the new one it is about the same, with an average height of 29 ft. from the foundation pedestals to the roadway. The arrangement of spans and position of foundations was governed largely by the location of the numerous tracks beneath the structure. The design was made under the direction of Mr. H. S. Crocker, M. Am. Soc. C. E., and the erection was under the direction of the firm of Crocker & Ketchum, of Denver. The contract for the manufacture of the superstructure was let to the American Bridge Co., of New York, and the erection was done by the Kelly-Atkinson Construction Co., of Chicago.

TRUSS SPANS.—The trusses are of a similar type to these of the 20th St. viaduct, described above, but of heavier proportions in view of the much greater loading. They are 26 ft. 8 ins. deep, and spaced 31 ft. 4 ins. between centers, giving a clear roadway of 28 ft. 2 ins. inside of the guard timbers. On one side is a 6-ft. sidewalk carried by cantilever brackets. The clear headway under the overhead struts is 24 ft. 6 ins. The floor-beams are 45-in. plate girders, 22 ft. 9 ins. long, and between these are four lines of 36-in. plate girder stringers for the tracks. Timber joists 5 × 16 ins. and 8 × 20 ins., resting on angle brackets, support the roadway outside of the tracks. The tracks have ties 8 × 8 ins., 8 ft. long, boxed out ½-in. over the stringers, and spaced 6 ins. apart in the clear. On these are 5-in. 85-lb. tee rails. The paving is a single course of 4-in. oak plank, the planks between the rails having the ends notched to form a groove for the wheel flanges. The sidewalk has four lines of timber joists and a 2-in. plank floor. The floor construction is shown in Fig. 9.

At the south end is a concrete abutment, but all the other supports are steel bents on concrete pedestals. The columns of these bents are built up of H-section (21¾ × 34¼ in.) with three plates,

four interior angles, and four flange angles (with lacing). The wider sides are parallel with the viaduct. Between each pair of columns is a 56¼-in. cross girder on which rest the 38-in. stringers. The trusses are carried by fixed and expansion-link pin bearings in the columns, as described for the 20th St. viaduct. Bents (1) and (3) have each two expansion bearings, while bent (2) has two fixed bearings; bent (4) has the fixed end bearing for the last truss and supports also the end of the adjacent 22-ft. girder span (tower span).

GIRDER SPANS.—This part of the viaduct has 11 deck plate girder spans of 26 ft. to 59 ft., five of which are tower spans. Some of the spans are on the skew, in order to put their supports clear of the tracks. The columns, 22 ft. 6 ins. apart, are built up of pairs of 15-in. channels, with lacing over the angles, and are connected by 66-in. cross girders. On these are five lines of longitudinal girders, the two outside girders resting on the columns, as shown in the cross section, Fig. 10. All of these are 4½ ft. deep, with the exception of the 22-ft. tower span at each of the trusses and the 59-ft. skew span, which have 3¼-ft. and 5¼-ft. girders, respectively. The two outside girders carry the plate-web cantilever brackets which support the roadway and sidewalk. Cross frames are placed between the girders at intervals of 13 ft., with lateral angle bracing in the plane of the top flange of the track girders. The space between the inside track girders is spanned by 10-in. I-beams riveted between the tops of the girders (in line with the cross frames), and these support the joists of the plan roadway. The width of roadway is 28 ft. 2 ins. between guard timbers, and the width of sidewalk is 6 ft. 3 ins., including the guard timber which forms the curb.

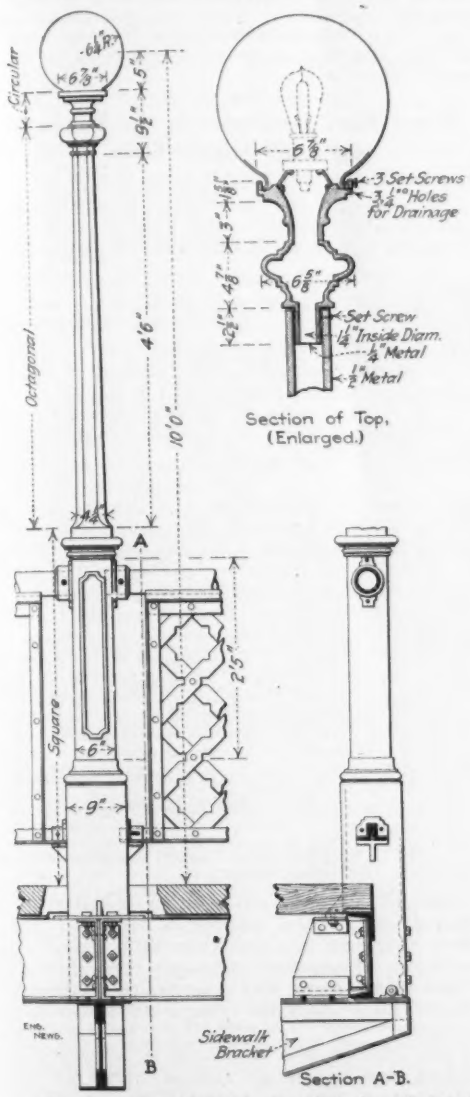


Fig. 8. Lamp Post for the 20th St. Viaduct; Denver, Colo.

In the tower spans, the bents are connected on all sides by bottom struts and diagonal bracing, with a vertical from the strut to the intersection of the bracing. There is also diagonal bracing at the bottom plane of the girders.

HAND RAILING.—The railing is less elaborate in design than that of the 20th St. viaduct, as will be seen by a comparison of Figs. 7 and 11. On the through trusses, the top and bottom bars of the railing are riveted to Z-bar brackets on the truss posts.

FALSEWORK.—The arrangement of the railway tracks to be crossed and of the bents supporting the ends of the old trusses made necessary an unsymmetrical arrangement of the falsework. For the 250-ft. spans each bent consisted of a cap and sill with six posts (all 12 × 12 ins.), and three 3 × 12-in. diagonal braces in each direction. On these bents were laid packed stringers and cross beams for the floor, as shown in Fig. 12, which shows also the position of the new and old tracks and trusses. This was the design for the use of a derrick car in erection, which plan was adopted. If a traveler was to be used, the cap and sill were to be extended and fitted with an additional post at each end, to make the base wide enough to support the rails of the traveler legs outside of the trusses, as indicated by the dotted lines. Some of the long bents, placed diagonally to the line of the viaduct in order to keep clear of the tracks, had the two middle posts vertical, while the two outer posts on each side were inclined to form an A-frame, having one foot against the vertical post and the head near the end of the cap. These inclined posts were 8 × 16 ins. To brace the feet of these posts, 4 × 8-in. sticks were laid upon the sills and fitted tightly between the inclined and vertical posts. Under the cap were two lines of horizontal plank bracing on each side, spiked against all the posts of the bents.

The stages of the erection of the first two truss spans were as follows: (1) jack the old spans and trestle to the new grade, (2) place the falsework bents under the two old spans, with stringers to support these spans, (3) block up the old spans at the floor beams, (4) remove the old trusses, (5) change the floor system and place new stringers to support the new floor beams, (6) erect the new trusses. The old timber viaduct bents were then remodeled (very much as shown in Fig. 13) to serve as falsework for the other two (north) truss spans, and upon this was erected the floor system of these spans. The trusses were then erected by means of a derrick car.

The falsework for the girder spans (Fig. 13) consisted of the old trestle bents enlarged and reinforced. As the grade of the new floor and tracks was above that of the old floor, the latter was raised temporarily about 5 ft. by means of pony bents, as shown. This enabled the old track to be used as a construction or derrick track during the erection of the new steel structure.

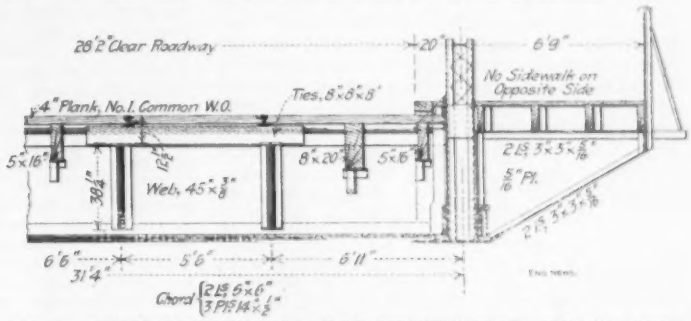


FIG. 9. CROSS SECTION OF FLOOR CONSTRUCTION ON THE NEW TRUSS SPANS OF THE 23RD ST. VIADUCT; DENVER, COLO.

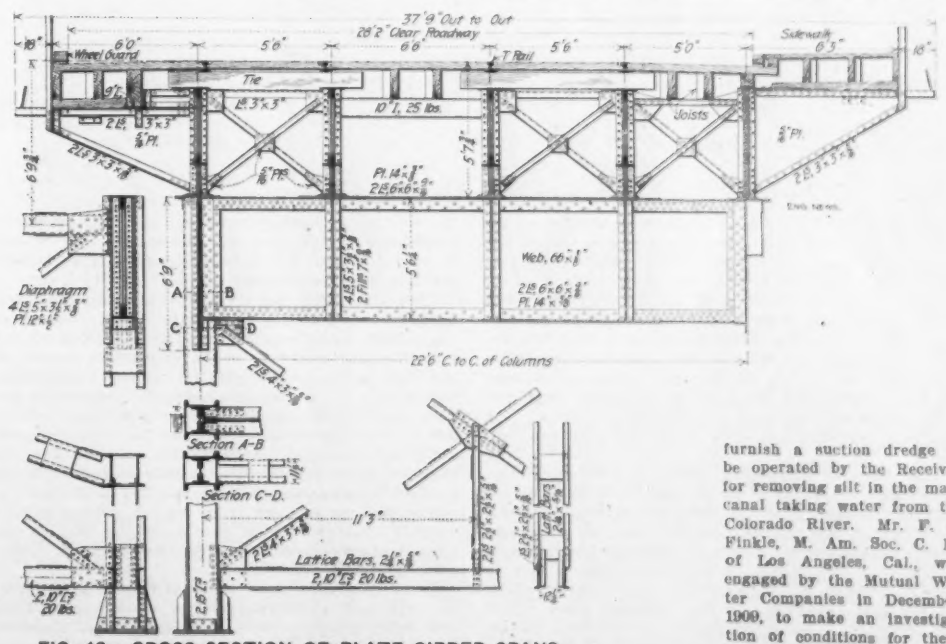


FIG. 10. CROSS SECTION OF PLATE GIRDER SPANS OF THE 23RD ST. VIADUCT.

AN INTERESTING SEWAGE-PURIFICATION PLANT has recently been installed at Melton Mowbray, England. The essential features of the plant are (1) settling or liquefying tanks with conical bottoms (2) rectangular-shaped percolating filters with rectilinear traveling distributors running on rails, worked automatically, (3) small settling tanks in duplicate, and (4) circular percolating filters provided with revolving distributors.

IRRIGATION WATER SHORTAGES in the Imperial Valley, Cal., during the past two or three years have led to some interesting emergency undertakings. Twelve Mutual Water Companies have been organized and have formed themselves into an association and made arrangements with the Receiver of the California Development Co. under which the Mutual Companies will furnish a suction dredge to be operated by the Receiver for removing silt in the main canal taking water from the Colorado River. Mr. F. C. Finkle, M. Am. Soc. C. E., of Los Angeles, Cal., was engaged by the Mutual Water Companies in December, 1909, to make an investigation of conditions for them. He found that there was four to five feet of silt in the main canal, extending from the Colorado intake at Hanlon's Gate down the canal toward the Imperial Valley for a distance of five or six miles. Mr. Finkle prepared plans and specifications for a suction dredge of 15-in. pump capacity, capable of handling 100,000 cu. yds. of material per month. The contract for this dredge has been awarded to the North American Dredging Co., of Los Angeles, at $57,400, the dredge to be completed before April 10, 1911. It is expected that the silt will be removed from the canal before low water of 1911, which occurs between July and September.

A Program for an Engineering Section at Future Conservation Congresses.

The President of the Engineers' Society of Western Pennsylvania appointed as delegates to represent the Society at the Second National Conservation Congress, at St. Paul, Minn., Sept. 5-9, 1910, Messrs. Alex M. Gow and Thomas H. Johnson, and in accordance with their instructions they have reported to the Society upon the Congress. The report is printed in full in the October "Proceedings" of the Society. In general, the delegates thought that too much time was given over to set speeches of undoubted fervor but of only general interest, while the real underlying purpose of the conservation movement was hardly touched upon. Realizing the very important part the engineering profession must play in this campaign, Messrs. Gow and Johnson were somewhat disappointed at the comparative obscurity of the engineer at the Congress and the lack of a definite program for the engineering features at this or at future similar Congresses. Their suggestions for such a program are reprinted, as follows, from the report:

We feel that the conservation of our natural resources should be removed from the realm of flamboyant oratory and brought where it belongs, into the field of engineering and business methods. If between now and the next meeting of the Congress the engineering societies of the country could get together and through wise counsel and cooperation lead to the creation of an Engineering Section of the Congress of 1911, they could make it an occasion for the presentation of the "conservation" idea along engineering lines, to the furtherance of the idea and the advancement of the profession. For while the promoter and the politician are necessary factors in the work, it is upon the engineer, after all has been said and done, that the solution of the problems and the shaping of them into concrete form devolves. The problems are many and cover every branch of engineering.

Just how the engineering phase of the conservation idea could be presented to the best advantage, we are not now prepared to state. This is a matter for study, consideration and consultation; but we beg to suggest that the Engineers' Society of Western Pennsylvania should take the initiative in a movement with a view to the presentation of the engineers' side of the question, at the next Congress. At that Congress there should be presented a series of papers by engineers, which papers shall be notable in that they shall record and recount the "state of the art" in the year 1911 and be valuable for reference as authoritative documents. Just how to get these papers prepared is a matter for this society to formulate, if it should approve of the suggestion and desire to set the ball rolling.

To illustrate: Let there be a paper upon the "Fixation of Nitrogen." Let this paper present the subject in its widest scope, telling what has been done, what is doing, and what are the hopes and possibilities for the fixing of atmospheric nitrogen for use as fertilizer. Over and over again at the Congress was the diminishing returns from our farming lands bewailed. The chemical engineer should be able to say much as to the possibilities of checking this by the use of nitrogen compounds from the atmosphere. Such a paper should be a "bench mark" as to the state of the art in 1911.

"Soil and Its Restoratives" might be the subject of another paper to enlighten the dear public on a subject upon which ignorance is not bliss to the farmer. Such a paper bears a close relation to that last mentioned, but there is a field for each.

And in connection with soil restoratives why not hear what our European brethren do in the way of fertilization from sewage? One of the questions frequently mentioned at the Congress was the pollution of our streams with its consequent waste of life, both human and aquatic. What has the engineer to say as to methods and means whereby this waste may be turned to advantage? This is a subject on which the general public have very little information, and on which the sanitary engineer could throw much needed light.

The introduction of practical forestry has called for the services of men of technical training whose function it is to explore and survey large tracts of timber, lay out and construct roads for transportation of logs and for fire lanes, organize and direct the system of patrols and fire protection, and advise clients in all matters pertaining to the preservation of wood in service. Such a man is entitled to be classed as an engineer, and a paper on these lines would be both interesting, instructive and profitable. The destruction of our forests by fire was frequently referred to in the various addresses at the Congress, but only in general terms. The paper just suggested should tell us specifically how forest fires may be prevented, how the forest should be patrolled, how roads and fire lanes should be laid out, how and where fire stations should be established, and their equipment, the method of fighting a fire once started, and, in fact, go into details of fire protection, with data as to costs per acre, number of men, etc.

While entomology and the study of bugs, beetles, butterflies and moths has never been looked upon as an engineering study, still it would be interesting to hear from the entomologist as to how he proposes to head off the gipsy moth, and prevent the waste and devastation that follows in the train of almost any insectiverous pest when once it gets rampant. Whether or not the entomologist can be classed as an engineer, he is an important factor in preventing the destruction of plant life, and should be given a hearing at the next Congress. He has a whole lot to say that is interesting and to the point.

What has the engineer to say on the question of food control? This will be a fine chance for him to tell what he knows upon a very important subject, closely allied to forest preservation.

At the Congress a great deal was said in a very general way upon the development of water power. Upon this whole subject there is far more general ignorance than information. It might be possible to throw some light into the darkness by presenting an outline of the engineering data necessary for consideration of any proposed development. The amount of power available from a stream, or water fall, is almost invariably overestimated and the cost of development underestimated. The public needs enlightenment.

Under the general theme of drainage and reclamation of swamp lands, there is a great deal to be said. A large amount of work has been done and is being done, and a description of the methods, results and costs, illustrated by dredges at work and ditches dug, might be a valuable contribution to the engineering literature on this important field of conservation.

Much has appeared in popular print and engineering literature relative to irrigation projects, but at the next Congress it would be well if the subject were reviewed and presented up to date.

As might have been expected, the corporations and "special interests" came in for not a little abuse at the Congress; the general impression being that the bigger the operating concern the less regard for economy and the greater waste. It might be well to point out that only operations on a large scale and backed by abundant capital can conserve raw material. Illustrations could be drawn from coal and ore mining and lumbering; and in this connection it would prove enlightening to most people to see, by means of moving pictures, a modern saw-mill in operation, from the log-haul up to the lath and box-board mill. If the pork packers "save everything but the squeal"; the saw-mill men save everything but the "bark," and some of that.

These are but a few of the subjects germane to the general subject of conservation which are primarily of interest to the engineer. They should be presented before the next Congress if Conservation Congresses are to be more than meetings for mutual admiration and opportunities for oratory.

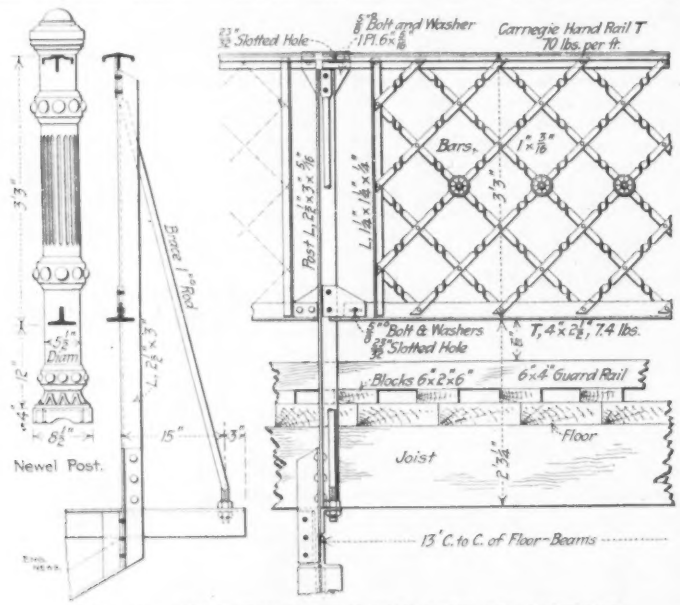


FIG. 11. HAND RAILING OF THE 23RD ST. VIADUCT.

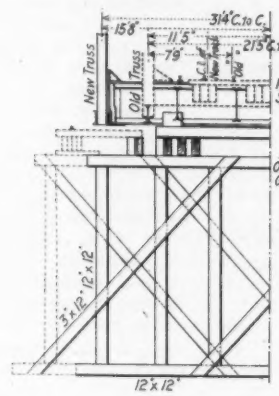


Fig. 12. Half Cross Section of Falsework for Truss Spans.

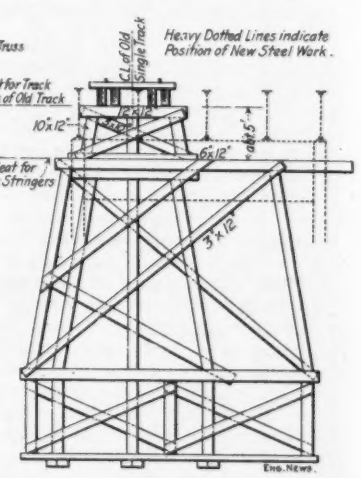

Heavy Dotted Lines indicate Position of New Steel Work.
New Seat for Track Stringers of Old Track
Original Seat for Old Track Stringers
10"×12"
6"×12"
3"×12"

Fig. 13. Falsework for the Plate Girder Spans of the 23rd St. Viaduct; Denver, Colo.

(The bents are the trestle bents of the old timber viaduct, strengthened for the purpose.)

Marine Wood Destroyers in the Waters of the South Atlantic Ports.

By W. D. FAUCETTE.* Jun. Am. Soc. C. E.

Some months ago the writer had occasion to make a study of the marine wood borer in the southern waters of the United States and in the course of the work carried on an extensive correspondence with a number of engineers who have had experience with these little destructive animals. From that study and from the correspondence there was compiled an extensive report, from which the present article has been prepared.

The engineer who is thrown in contact with wharf construction, or uses of timber of any character, in the warm waters of the Gulf Stream or Atlantic Ocean, will quickly realize that he must protect, not only against the ravages of time and wear and tear, but also against marine animals that represent a form of life which foster ill will against unprotected or untreated timbers. It is more than likely that the engineer who has been reared and educated in colleges or in the practice of inland states, remote from the coast, has only a formal acquaintance, through books, with the inhabitant that he will no doubt later meet face to face in a fierce battle for preservation of property.

It does not seem that these marine enemies are of recent knowledge. The teredo was mentioned in the writings of Pliny and of Ovid. Also, in 1778, "The Report of John Smeaton, upon the state of the Bridlington piers, England, with the most probable means of preserving the same from destruction of the worms," (dated May 15, 1778), indicates that troubles were be-

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ing then experienced in England. In his reports (v. 3, p. 192, London 1812), a recommendation reads, "There are still larger detached piles which are equally eaten away by the worms as the other; to those I would only advise that their whole surface on every side be driven or filled with sheathing nails from a little below ground to near neap tide mark as before recommended." It is also of record that one William Chapman, in a report to the Admiralty, dated from Newcastle, Eng., June, 1817, recommends the mopping or brushing of piles from ground level to above low water, with whale oil as a preventive against the sea worm."

In our waters, we have two genera of mollusks and three of crustaceans that seriously damage marine structures. The various species and their habitat are as follows:*

Teredo Navalis: Between Florida and Cape Cod.
Teredo Norvegica: Cape Cod northward to Maine.
Teredo Megotara: New Bedford, south to South Carolina.
Teredo Dilitate: Massachusetts to South Carolina.
Teredo Thompsoni: Massachusetts.
Xylophaga Dorsalis: North Atlantic.
Xylotrya Fimbriata: Long Island Sound to Florida.
Xylotrya Gouldi: Found everywhere.

These just cited are popularly called ship worms, and the teredo and xylotrya are much alike. The eight names given belong to the mollusk family. The crustaceans are:

Limnoria Terebrans: Nova Scotia to Florida.
Chelura Terebrans: Massachusetts.
Sphaeroma Destructor: Noted in Florida.

The limnoria is sometimes called wood louse, gribble or boring gribble.

The following is a short reference from a paper of Dr. Charles H. Snow, of New York University, which relates to the description of the teredo and limnoria.

The body of the teredo, which in substance resembles that of an oyster, is long, slender, smooth, soft and gray, tapering somewhat toward the outer or posterior end. . . . It will be seen that the destructive features of the teredo are the body, collar, siphons, the pallets, the boring shell, the foot and lining shell. . . . The size depends upon species, locality and age, etc. . . . The teredo continues to grow until it reaches its maximum size, unless an obstacle is encountered. The species "nevalis" may be assumed to average from about ¼-in. to ⅜-in. diameter and from about 10 ins to 15 ins. in length, but species of teredo frequently attain a much greater size.

The limnoria is about as large as a grain of rice. The body is flat, round at each end and consists of 14 segments. The sides are nearly straight and are parallel to one another. To each of the seven segments which follow the head, is attached a pair of short, stout legs, terminating in claws, the shape of which suggests the small claws of the lobster. The upper surface of the body is covered with small hairs, to which more or less dirt usually adheres. The body is grayish in color and sometimes resembles the color of the wet wood, so much so that it is difficult to distinguish it. The limnoria can swim, creep backward and forward, as well as jump backward, by means of its tail. When touched it rolls itself into a ball, and in this particular as well as in general appearance, it resembles the common "sow bug."

Below is given a list of the various ports where the ravages of these animals are known, with the local name, and the authority who furnished the information:

New York: Teredo and limnoria. (C. W. Staniford, Chief Engineer, Dept. of Docks and Ferries.)
Norfolk, Va.: Teredo and limnoria. (W. L. Seddon, Chief Engineer, Seaboard Air Line.)
Charleston, S. C.: Teredo and limnoria. (J. H. Dingle, City Engineer.)
Savannah, Ga.: Teredo. (A. S. Cooper, U. S. Engineer.)
Brunswick, Ga.: Teredo navalis. (E. R. Conant, U. S. Engineer.)
Fernandina, Fla.: Limnoria and teredo. (L. R. Hoyt and H. H. McCrary.)
St. Augustine, Fla.: Limnoria and teredo. (E. B. Carter, Florida East Coast Ry.)
Palatka, Fla.: Sphaeroma destructor. (E. B. Carter, Florida East Coast Ry.)
Miami, Fla.: Teredo and limnoria. (E. S. Frederick, City Engineer.)
Key West, Fla.: Limnoria. (W. A. Gwynn, City Engineer.)
Tampa, Fla.: Limnoria and teredo. (W. H. Caldwell, Civ. Engr.)
Pensacola, Fla.: Limnoria and teredo. (W. T. Duncan, Louisville & Nashville Ry.)
New Orleans, La.: Teredo. (Lieut.-Col. L. H. Beach, U. S. A.)
Galveston, Texas: Teredo. (A. C. Dickey, City Engineer.)
San Juan, P. R.: Teredo navalis, limnoria, terebrans and a small bug called the lepisura. (A. Stierle, U. S. Asst. Engineer.)

*Authorities: U. S. Fish Commission; Dr. Snow, New York University.

At a glance this shows that taken as an index, the problem of wooden wharf or marine structure at these points and intermediate ones becomes a serious difficulty, especially in view of the ravages and havoc played by these borers.

Below are the names of places, and on the first line after it the period after placing in water that timber and piles show signs of attack; the second line shows the quickest time where a pile placed failed and deserved replacing. The authorities, whose names are given, are those quoted above:

NEW YORK:
Attack not particularly noticed for 1 or 2 years, but if water is clear from impurities, attack may come at any time.
Piles on record eaten to destruction inside 8 years, Lower New York Harbor. (Staniford.)

NORFOLK:
Almost immediately attacked.
Quickest failure, about six months. (Sedden.)

CHARLESTON, S. C.:
Peeled piles show sign of attack in 3 months;
Dangerous after 18 months. (Dingle.)

SAVANNAH, GA. (Sea):
After the first summer shows attack.
One year, deserved replacing. (Cooper.)

FERNANDINA, FLA.:
Can notice attack in one season.
Replaced in 3 years' time. (Hoyt and McCrary.)

FLORIDA COAST:
Knows limnoria to attack in 48 hours.
Will last 7 months, mouth St. Johns River.
Will last 11 months, San Sebastian River.
Will last 20 months, St. Lucie River. (Carter.)

MIAMI, FLA.:
Very soon show attack.
Quickest time, 7 months before failure. (Frederick.)

KEY WEST, FLA.:
Three months show attack.
Between 3 and 4 years, before deserved replacing. (Gwynn.)

TAMPA, FLA.:
Show attack in 6 months.
Failed in one year. (Caldwell.)

PENSACOLA, FLA.:
In summer, show signs in about 3 or 4 months.
Quickest failure, less than one year. (Duncan.)

NEW ORLEANS, LA.:
Places known to show attack within a day or two.
Known piles in West Galveston Bay to require replacing within less than one year. (Beach.)

GALVESTON, TEXAS:
One or two months before attack.
Complete failure in six months. (Dickey.)

SAN JUAN, P. R.:
Ordinary piles last approximately 18 months.
Known them to deserve replaceal in 6 months. (Stierle.)

In looking over these data care should be taken to note that this refers to quickest time of attack and replacing, and that piles may last longer under varying conditions.

The methods of protection against the borers are numerous and varied, but it is of interest to note, that creosoting stands in the front ranks of preservatives now in use. Records show varying results from 20 to 40 years as the life of piles creosoted. In a conclusion drawn (1908) by the U. S. Forest Service, it advises that creosoted material for piling should be extended. The Forest Service further says that at present creosote and zinc chloride, pure or in mixture, are the only wood preservatives which are in general use. It may be of special interest to note that while several of the correspondents noted above mentioned various methods of protection, not one omitted to say that creosoting is one of the methods now most used.

In the accompanying table is given the distance of the Gulf Stream off shore and the pounds per cubic foot of creosote thought ample for protection.

	Pounds of Oil Recommended.	Distance of Gulf Stream from Coast.
Miami (Bay)	20-28	5
Fernandina (Entrance)	24	63
Savannah, Ga. (Tybee)	20	67
Charleston, S. C.	20-22	55
Wilmington, N. C.	20	56
Norfolk (Cape Henry)	20	115
Atlantic City, N. J.	16	119
New York (Sandy Hook)	12	123

Note that the amount of pounds per cubic foot of wood to amply preserve it, is inversely proportional to the distance of the Gulf Stream away and inversely proportional to its latitude. This is, however, simply the facts as we find them and no law seems to fit the exact inverse ratio, an inspection indicates the curve of comparison very irregular. In examining a record of certain items of preservation work for 1909, the comparison of creosoted treatment of piling, lumber and bridge timber, is as follows:

	Creosoted.	Zinc Chloride.	Zinc Oil.
Piling (in ft.)	6,960,400	....	630,800
Lumber, ft., B. M.	72,800,000	1,150,800	430,300
Bridge timber, ft. B. M.	16,230,700	840,070	....

No mention is made of various other methods that may have been used; probably their use has not been sufficiently extended to cover many units of piling, etc. Of the totals above, it is noted that of the whole, creosoted piling was 90% of the whole reported; creosoted lumber, 97% of the whole reported; and bridge timber creosoted was 95% of the whole. It was considered that the estimates were 10 to 15% too low, as representing the whole scope of preseration work in 1909, several companies failing to make returns. This would probably not alter the percentages just given (see Engineering News, February 3, 1910, p. 151).

It must be understood that any complete exterior coating is effective as long as completely intact. One break or hole lets the enemy enter, and experience seems to teach that exterior coatings are subject to abrasion from floating objects, waves, etc. Once the coating is pierced the damage is done and you are open to attack. Be the sheet of protection ever so thin, it is effective if unbroken, but this is an ideal condition and external coatings must sooner or later give way and, therefore, the creosoted methods, and concrete encasements with pipe seems to be more efficient in the long run and test of time.

Remembering that the enemy attacks largely between high and low water, or certainly between high water and mud line, it is evident that the business world will welcome a cheap efficient treatment that will wear and preserve the pile and only have to be applied to the zone of probable attack, instead of the whole pile, as now, in the case of creosoting.

This paper only touches upon the main features of the marine borer question as they presented themselves to the writer. It has been the endeavor to collect and present a few facts as a guide and stimulate some interest in this very absorbing subject. When wooden piles are totally replaced by concrete or steel structures, this problem will not be so vital to us, but as long as piles and timber are used in the warm waters of the South Atlantic and Gulf Stream, some means must be adopted to preserve economically the structure proposed. These troubles are only in sea water. The concensus of opinions at hand show that these borers are most pernicious where the water is calm, salt and warm, with a degree of clearness, free from mud and heavy pollution. In fresh water there is no trouble with these borers, hence our problem is confined to seaports exclusively.

For the facts presented, the writer is indebted to each of the gentlemen whose names are given at places above. They have sent many answers to questions and without their help this paper could not have been prepared. He is also indebted to the Secretary of the American Society of Civil Engineers, and to the pamphlets issued by Forest Service of the Government, as well as other periodicals, etc., from which data have been drawn and collected.

The North Shore Drainage Channel at Chicago.

The completion of the North Shore drainage channel (into which water was admitted on Nov. 29, 1910) adds an important auxiliary to the Chicago main drainage canal. It is an important addition also to the sewage-disposal and water-supply protection system of the city of Chicago. It provides for taking the sewage of Evanston and other residence towns north of the city (but within the Sanitary District), and discharging it into the Chicago River, through which it flows to the main drainage canal. This sewage has until now been discharged into Lake Michigan, to add to the pollution of the city's water-supply.

The current from the canal will serve also to flush out the north branch of the Chicago River, which has long been in an extremely foul condition. After the opening of the main drainage canal in 1900, the black water of the main channel and south branch of the river very soon gave place to clear water. At the junction of the main channel and the north and south branches, therefore, there has been a distinct line of demarcation between the current of clear green water and the body of black (and practically stagnant) water of the north branch. This curious feature of the Chicago River will now disappear.

The purpose and location of the North Shore Channel were explained by Mr. Isham Randolph, M. Am. Soc. C. E. (Consulting Engineer for the Sanitary District of Chicago) in his comprehensive article on "The Chicago Drainage Canal," in our issue of July 22, 1909.

The new channel commences at the lake shore at Wilmette, Ill., and extends west and south to the north branch of the Chicago River at Lawrence Ave. Its length is 8¼ miles, with 12 to 13.6 ft. depth of water. The width is 26 to 30 ft. on the bottom, 75 to 100 ft. at water line, and 120 to 140 ft. at the top of the cut. The average depth of cut is 28 ft. It is crossed by 21 highway bridges and three railway bridges, all giving a clear headway of 16 ft. The right-of-way is generally 660 ft. wide, and most of it was acquired at appraised rates without condemnation. The last piece of property was not obtained until June, 1910. Work on the canal, however, was commenced as soon as enough ground was available for starting one steam shovel, instead of waiting until all the property had been secured. In this way, the canal was completed at least two years sooner than would have been possible otherwise.

Excavation was begun at the Wilmette end in April, 1908, by a steam shovel belonging to the Sanitary District. For construction purposes, the channel was divided into 12 sections, varying in length from ¼-mile to one mile. The total volume of excavation was about 3,475,000 cu. yds. Of this amount, about 800,000 cu. yds. in Sections 1 and 2 (through Wilmette and Evanston) was hauled and dumped into the lake north of the intake harbor. This filling forms an area of about 600,000 sq. ft. of reclaimed land, which is enclosed by breakwaters. The remainder of the excavation was deposited in spoil banks along the channel, and an agreement has been made for the removal of this material by a brick company.

FIG. 1. EXCAVATION ON THE NORTH SHORE DRAINAGE CHANNEL; CHICAGO.

FIG. 2. COMPLETED PORTION OF THE NORTH SHORE DRAINAGE CHANNEL.

(With the pumps in operation the water level will be about 3 ft. higher.)

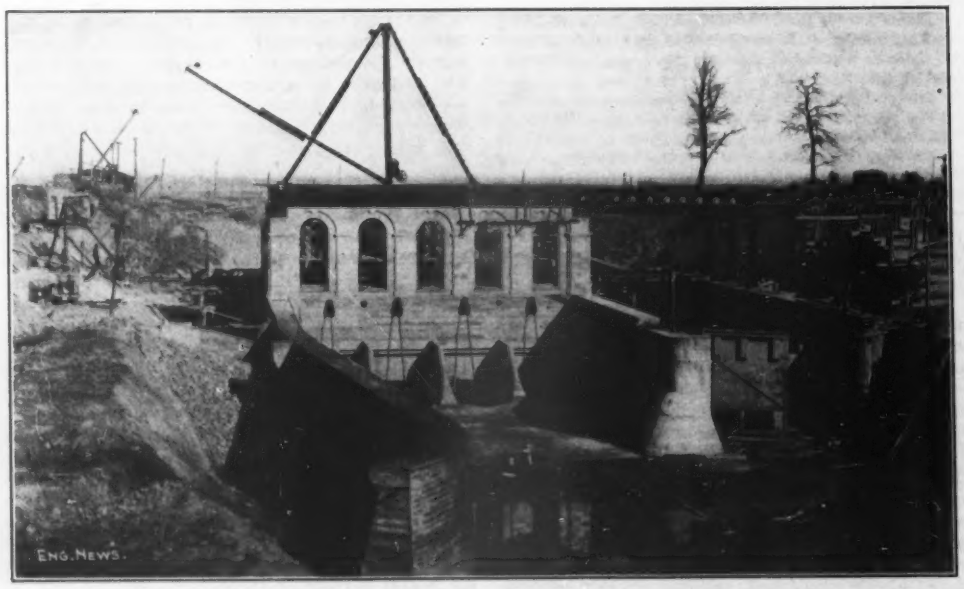

FIG. 3. PUMPING STATION AND LOCK AT WILMETTE, ILL.; THE LAKE MICHIGAN END OF THE NORTH SHORE DRAINAGE CHANNEL.

On sections Nos. 1, 2, 10 and 11, the work was done by the forces of the Sanitary District, using steam shovels and dump cars. The same forces also completed section No. 7. Section No. 8 was excavated in part by steam shovels (served by the Woodford System* of electrically operated dump cars under control from a distance) and in part by a cableway scraper-excavator. The remainder of the channel was excavated by scraper-bucket or drag-line bucket machines. The entire excavating plant consisted of five 70-ton steam shovels, 7 scraper-bucket excavators and one cableway excavator.

The work was almost entirely in the Chicago blue clay. No rock was encountered, but at some points there was a seam of soft wet clay at about the level of the bottom of the canal. Under the weight of the overlying material and the spoil banks, this squeezed out and led to some slides, with consequent subsidences at a little distance from the cut. Fig. 1 is a view (near Peterson Ave.) of the work in progress, with one of the scraper excavating machines at the right. Fig. 2 is a view of a completed portion (north from Emerson St.). The water as shown is at approximately lake level, but will be about 3 ft. higher when the pumping plant is in operation.

In order to dilute the sewage in the channel to an inoffensive condition, as well as to flush the north branch of the river, the channel will carry a flow of lake water of 1,000 cu. ft. per sec. This flow requires an initial or total fall of 3 ft., which is produced by a pumping station at the lake intake. The pumping plant consists of four Allis-Chalmers horizontal shaft screw pumps 9 ft. in diameter. Each pump has a capacity of 250 cu. ft. per sec. at 75 r. p. m., and is geared to an electric motor of 150 HP. These motors are three-phase, 60-cycle, 100-volt machines. Each pump is at the lake (or intake) end of a conduit passing under the pumping station, the tops of the conduits being about level with the bottom of the channel. The pump shaft passes through the curved wall of the conduit into the gear pit of the pumping station. The discharge end of each conduit is fitted with a gate or flap valve to prevent back flow (due to the 3-ft. ex-

*Engineering News, Oct. 21, 1909.

cess elevation) in case of stoppage of the pumps. Power for the pumping plant is supplied by the Sanitary District from its hydro-electric plant at Lockport and over its own transmission line, a distance of 46½ miles. The Sheridan Road is carried over the pumping station by a bridge of ornamental design, forming a part of the station.

The channel itself does not open into the lake (owing to the difference in water level), but adjacent to the pumping station there is a lock 32 ft. wide and 130 ft. long to provide for navigation against the 3-ft. lift. In order to prevent choking of the lake intake by sand due to storms, and to prevent such sand deposits from being carried through the pumps into the canal, the entrance is protected by crib and pile breakwaters extending 1,000 ft. into the lake.

Fig. 3 is a view of the channel side of the pumping station, showing Lake Michigan in the distance. Beneath the windows are the four discharge openings of the pump conduits, with their flap valves. At the right is the lock. The derrick stands on a portion of the steel bridge which is to carry the Sheridan Road over the station.

The estimated cost of the channel was $3,000,000. The actual cost was $2,770,000, distributed as follows:

Channel construction, including bridges, harbor, etc.	$1,600,000
Pumping station and plant	250,000
Right-of-way, engineering, etc.	920,000
Total	$2,770,000

During the entire period of construction Mr. R. R. McCormick was President of the Sanitary District; and Mr. Geo. M. Wisner, M. Am. Soc. C. E., Chief Engineer. Mr. L. K. Sherman, M. Am. Soc. C. E., was Assistant Engineer.

The New Central Reservoir of the People's Water Company, Oakland, Cal.

By C. H. PARK,* and G. S. JACOBS.*

The People's Water Co. of Oakland, Cal., has recently completed a concrete-lined distributing and equalizing reservoir of 150,000,000 gals. capacity, the largest on the Pacific Coast. It is located in East Oakland in a rapidly building residence district with a high water elevation of 198.5 ft. above Oakland city base, and is supplied through a 36-in. riveted steel pipe line a mile and a half long from the 24th Ave. Pumping Station, which draws on the company's main conduits from Lake San Leandro and Alvarado wells. The supply mains to the city are also connected to the discharge of this pumping station so that Central Reservoir will fill during periods of low draught, and will supply the deficiency in periods of high consumption, incidentally providing a storage of eight days' supply under high pressure for all of the lower parts of the city of Oakland.

The reservoir was created by throwing an earth dam across a former creek bed, the waters of which at one time drained into Sausal Creek. Ample provision for the disposal of the surface drainage from above the reservoir is provided by the street sewers in this part of the city. The side slopes of the natural basin were then graded uniformly, as shown in Fig. 1, and the whole interior of the reservoir, side slopes, dam slope and bottom covered with a layer of concrete. This forms a basin 1,500 ft. long by 800 ft. wide, covering nearly 20 acres. In all over 200,000 cu. yds. of earth were moved and about 100,000 sq. yds. of surface concreted.

The dam is 25 ft. wide at the top, 56 ft. high and about 900 ft. long, with slopes of two horizontal to one vertical on both sides. The outside slope is to be sodded and planted to prevent erosion and the inside slope is covered, as noted above, with a 6-in. facing of concrete, terminated at the bottom by a concrete cut-off wall, 2½ ft. thick, and varying in depth from 6 ft. at the middle to 20 ft. at the ends. This wall is bonded well into the concrete lining of the slope face. The paving on the graded slopes is 4 ins. thick and is placed in the same manner as that on the dam slope, viz., in 12 ft. square slabs, with joints made of "D" grade asphaltum mixed with carbolated lime and run hot.

Construction was commenced in July, 1909, and, with the exception of the short rainy season of the following winter, was pursued continuously to completion in October, 1910. Test pits were sunk to a depth of 40 ft. on the site of the dam and at other parts of the reservoir site and disclosed alternate layers of varying thickness of mixed sand and gravel with clay, in large quantities, which after excavation, placing on the dam, and rolling, formed an excellent and compact clay puddle, of which practically the entire dam is built. The base of the dam was excavated to a depth of 15 ft. below the original surface. Earth was removed at first with a 2½ yd. 70-ton steam shovel, emptying into bottom dump wagons which deposited their contents on the dam in layers of 6 to 12 ins. in thickness, over which a 12-ton steam roller worked continuously. Later, in the final grading of the side slopes a 16-horse drawn gasoline operated grader was used in conjunction with plows and scrapers. For a period of over three months, the steam shovel and dump wagons handled an average of over 1,000 cu. yds. daily.

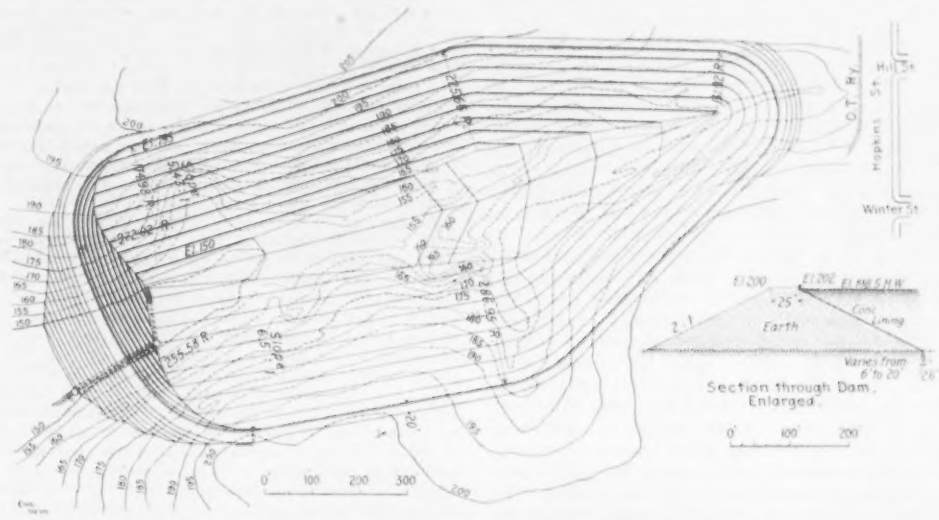

FIG. 1. PLAN OF CENTRAL RESERVOIR, PEOPLE'S WATER CO., OAKLAND, CAL.

All the side slopes of the basin where fills had been made were compacted with a steam roller before the finish grade was set.

To eliminate the danger due to exposed pipes in an earth embankment, and to provide for leakage of the same and inspection, a concrete culvert of arch section 8 ft. in diameter, with cut-off ribs, runs through the dam and carries, on concrete piers, two 24-in. cast-iron mains for supply and one 16-in. main for sluicing and drainage of the reservoir. By means of a lead expansion joint, embedded in the concrete, the culvert is joined to a concrete gate tower at the inside toe of the dam. This tower is 6 ft. inside diameter with walls 2 ft. in thickness, 56 ft. high with 30 × 30 Coffin sluice-gates at three levels, operated from the gate house above by bevel-geared ball-bearing stands. The tower is surmounted by a rustic-finish wooden gate house and is reached from the dam over a wooden foot bridge of two 33-ft. spans with a center bent 19 ft. high. As the lower part of the gate tower is in embankment, it was necessary to connect the lowest level of the reservoir floor to the outlet tower by a small concrete-lined tunnel 3 ft. by 4 ft. in section. The inlet of this tunnel is at an elevation of 146.5, thence it drops on an easy grade to a sump where the blow-off pipe is located, and the remaining 20 ft. rises to the tower at an elevation of 150. By this arrangement, all the sediment will be left in the sump where it can be blown off.

The rim of the basin is enclosed by a concrete wall 4 ft. high built in 12-ft. sections with joints of building paper and asphaltum. The wall carries an ornamental iron fence and will ultimately be surrounded by a road-way. In time, the adjacent slopes will be parked and probably dedicated to public use. At elevation 198.5 an overflow basin is arranged to discharge into a 24-in. terra-cotta drain to a storm sewer on Central Avenue.

Of two springs uncovered in the progress of grading near the center of the reservoir, the larger one was excavated to its gravel bed, from which an 8-in. vitrified drain was laid to the

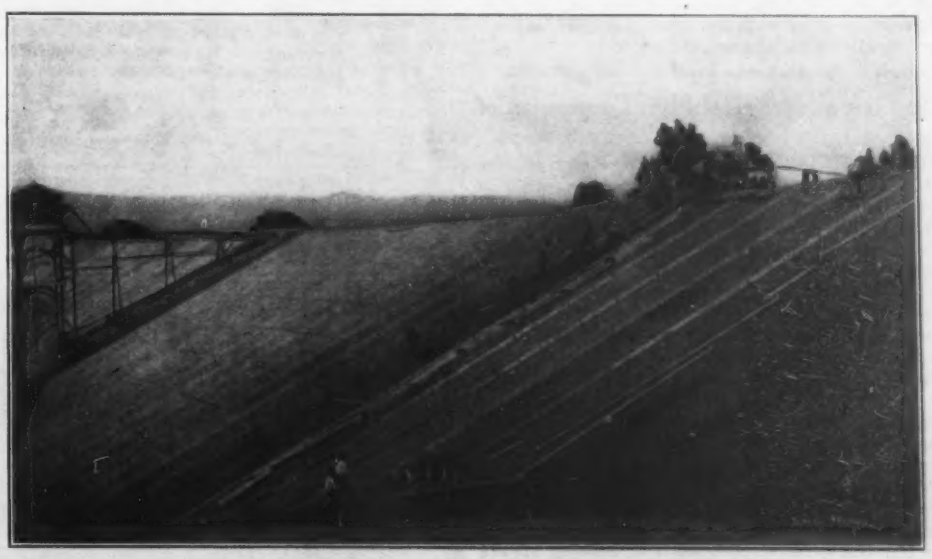

FIG. 2. VIEW OF CONCRETING ON SIDE SLOPE.

*Assistant Engineers, People's Water Co., Oakland, Cal.

blow-off pipe of the reservoir. This ensures proper sub-drainage and is in no way affected by the opening or closing of the valves. The other small spring was excavated to gravel and the hole back filled with tamped clay. This completely checked the flow of the water and no further trouble was experienced.

All structural concrete for the tower, culverts, tunnels, etc., was mixed in proportion of 1: 2: 4. The culvert was reinforced transversely with ⅝-in. round rods spaced 16 in. c. to c. and longitudinally with the same size rods and spacing. Concrete for the lining was mixed in proportions 1: 2½: 5 using an electric-motor-driven mixer of about 18 cu. ft. capacity, located on the upper rim of the reservoir, and shifted from time to time to follow the work. For a period of 63 consecutive days an average of 162 cu. yds. daily, was mixed and placed in 9 hours, corresponding to one batch every two minutes. The best day's work was 246 cu. yds. in place. The mixer was fed by a 21 cu. ft. loading-car hauled up an inclined track, and the mixer discharged into a train of five dump cars of 16 cu. ft. capacity, each. From the mixer, the cars were moved by horse to the edge of the slope, and while still in motion the horse was unhitched and the cable of a steam-hoisting engine attached, by means of which the cars ran to any part of the slope. On account of the steep slope of the inner face of the dam, the concrete for its facing was run down a chute instead of employing the cars. The concrete was then dumped on the finished earth slopes into slabs, the only forms necessary being 2x4¼ in. surfaced pine boards, 12 ft. c. to c., laid on edge. The concrete was tamped and left rough. When the concrete had set slightly, the forms were removed and a wooden wedge-shaped strip (⅞ × ⅝ × 3-in.) was inserted in its place and the concrete filled in about it. After the concrete was completely set, these strips were removed and the asphalt joint poured. Embedded in the concrete in the bottom of the reservoir is a 3-in. water pipe with hydrant taps for flushing the sides of the reservoir. This was conveniently employed in wetting the concrete lining during setting.

The plans for the structure, except the minor details, were prepared by Mr. A. Kempkey under the direction of Mr. A. L. Adams. The reservoir was built by the Piedmont Construction Co. of Oakland, Cal., under the direction of Mr. G. H. Wilhelm, Chief Engineer of the People's Water Co., with Mr. Chas. H. Park, Assistant Engineer, in charge of the work.

The Civic or Municipal Plans Commission of Seattle, Wash.

Under a recent amendment to the city charter of Seattle, Wash., there has been created a civic, or municipal, plans commission composed of 21 citizens chosen to represent various public and private interests in the city and county. The city and county authorities, the chamber of commerce, the banks, real-estate, water-front, harbor and manufacturing interests, as also the legal and architectural professions and the steam and electric railways, each and all have representation on the commission. Mr. R. H. Thomson, M. Am. Soc. C. E., City Engineer of Seattle, is also a member. The commission has appointed various sub-committees which, after investigation, will report back to the main commission.

The following outline of the general plans of the commission, so far as yet formulated, is from an article in the Seattle "Town Crier," written by Mr. Norwood W. Brockett, a member of the commission, as we understand it, representing the electric railways:

The Commission has taken as its standard a city of 1,000,000 people, extending from the King County line on the north to Orillia on the south, to Newcastle on the east and to the Sound on the west, embracing an area of approximately 150 square miles of land. For this prospective city the Commission is trying to establish arterial highways, quick transportation, parks, boulevards, playgrounds and a civic center accessible by easy grades from all points.

The greatest labor will be expended upon the water front, as it is from this source that Seattle's future greatness and prosperity must come. With one of the finest natural harbors in the world, Seattle has probably done the least of any city of like size towards its ultimate development. With the opening of the Panama Canal the city with the best dockage facilities and the quickest and most economical methods of handling freight will soon seize the commercial supremacy of the Pacific coast. This cannot be done by individual enterprises without the city's first adopting and laying out a systematic development of the entire harbor as a unit, and it is this which the Commission hopes to accomplish.

There are four essentials which go to make up a great manufacturing city: Transportation to the market, cheap power, available sites and the labor problem. The location of this city and the numerous surrounding water powers have solved the first two of these problems; the last two must be taken care of by the citizens of Seattle. The sites must be in close proximity to both water and rail transportation; to accomplish this the harbor area must be extended either by the Duwamish or the North canal, or both, and ample provision must be made for railroad terminals, switch yards and sidings. A limited area available for manufacturing sites necessarily means a high valuation, which often precludes the establishment of factories which would otherwise be erected.

The labor problem has been solved in other cities, and must eventually be solved here, by making Seattle a cheap and attractive place in which the man who labors in the factory can live and raise his family; the more congested the population the more unsanitary are the homes of the working men, which necessarily leads to disease and discontent. The suburbs of this city must be opened up to provide for reasonable building sites and reasonable rents for the working man. In addition to this the transportation facilities must be such that he may reach his place of employment in the morning and his home in the evening without unnecessary delays and at reasonable transportation charge. Parks and public playgrounds must be built, as it is rapidly becoming apparent that the physical development of the child is fully as important as the mental. All these are some of the problems which the Commission is trying to solve, and not merely the location of the city hall or the county court-house, as seems to be the popular belief.

Few immediate public improvements are planned by the Commission, but it is its aim to lay before the people a comprehensive plan for a future great city; to submit maps showing the location of future docks, waterways and railroad yards, arteries of travel, boulevards, parks and playgrounds, so that as the territory contiguous to the present city is opened up and becomes a part thereof, it can be platted to conform to every other part of the city, thereby forming a unit which if rightly planned and successfully carried out will make Seattle not only a great commercial city, but a beautiful and healthful place in which to live.

The beautiful city pays and pays handsomely in money dividends. This is no longer a debatable question, as it has been answered affirmatively by every city which has made the experiment. It pays in health and the happiness of its inhabitants, in the increased value of property, in the lure of population to it as a place of residence, in the drawing of industries to it because they find educated and contented men to operate them.

The charter provided that the Commission shall employ an expert to assist it in its work. The reason is obvious. If the city is to be planned as a whole, it is essential that all local prejudices and influences be eliminated. In addition to this the establishment of a harbor, the planning of a city and the location of railway terminals has become a profession, followed by men who make them a life study.

At the commencement of its labors the Commission was singularly fortunate in securing Virgil G. Bogue of New York to systemize and direct its effort. While Mr. Bogue's reputation is international, he is particularly well known in this vicinity by reason of his having laid out and constructed the Northern Pacific Railroad over the Stampede Pass and from Tacoma to Seattle. Seattle is also indebted to him for his wonderful foresight in laying out the present Seattle Harbor over 22 years ago.

Mr. Bogue, like most men who have spent much of their lives in the open, is reserved, modest and undemonstrative; his pride in his present work is, however, very great and his belief in the future of Seattle unlimited. He believes that it has tremendous natural advantages and expects with the aid of the Commission to submit a plan which, if adopted, will utilize these advantages to their utmost, and make Greater Seattle a magnificent seaport and a great manufacturing city.

Diagram Showing Results Given By the Imhoff Sewage-Clarification Tank at Bochum, Germany.

One of the Imhoff sewage-clarification tanks in the Emscher District of Germany (see Eng. News, Dec. 1, 1910), is located at Bochum. Through the courtesy of Mr. Rudolph Hering, M. Am. Soc. C. E., of New York City, we are enabled to present a diagram showing the results obtained by this tank. As will be noticed, the percentages of reduction of suspended matter are based, not on the total matter in suspension, but on "the suspended matter capable of settling," which Mr. Imhoff thinks a more expressive form of statement. Another unusual feature of the diagram is the curve showing the line of detention. It will be noted that this was short, and that remarkably good and fairly uniform results were obtained in short periods and with considerable fluctuations in time.

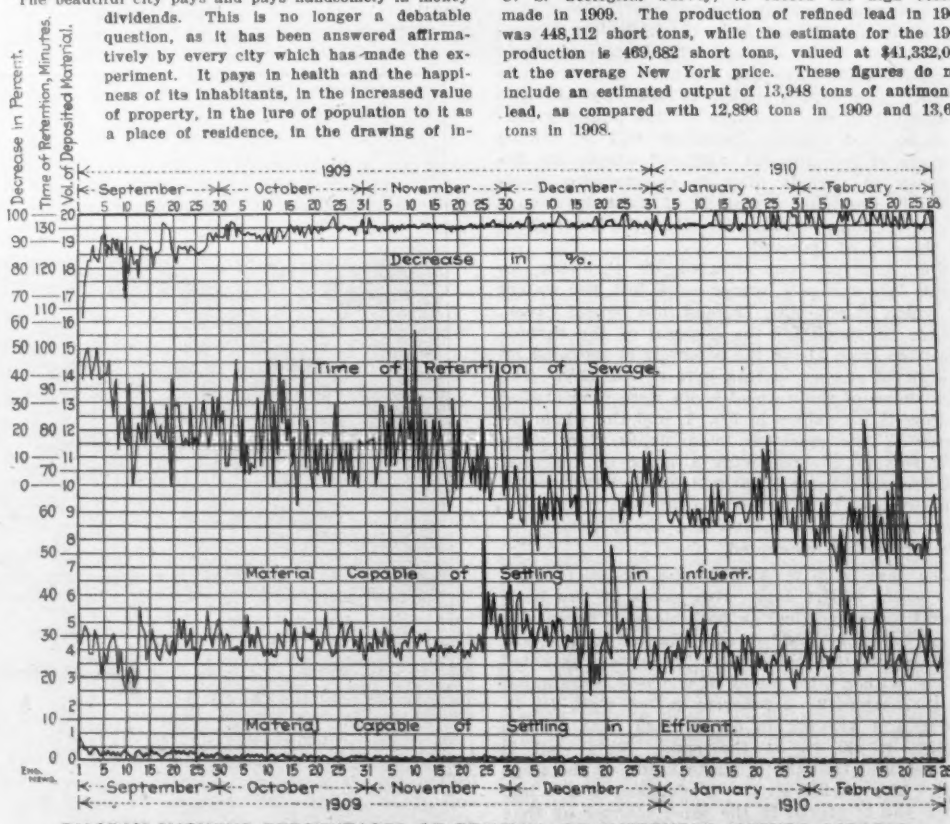

DIAGRAM SHOWING PERCENTAGES OF REMOVAL OF SUSPENDED MATTER CAPABLE OF SETTLING AND PERIODS OF DETENTION, IMHOFF TANK AT BOCHUM, GERMANY.

THE PRODUCTION OF LEAD in the United States in 1910 is estimated by Mr. C. E. Siebenthal, of the U. S. Geological Survey, to exceed the high record made in 1909. The production of refined lead in 1909 was 448,112 short tons, while the estimate for the 1910 production is 469,682 short tons, valued at $41,332,016 at the average New York price. These figures do not include an estimated output of 13,948 tons of antimonial lead, as compared with 12,896 tons in 1909 and 13,629 tons in 1908.

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Events of the past few years at Montreal would make it quite appropriate for local almanac makers to insert "About this time look out for typhoid fever." There is reason to expect, however, that Montreal will escape its usual winter outbreak of this disease, owing to the installation some months ago of a plant for treating the water-supply with hypochlorite. The reports of typhoid cases in Montreal during January and February will be awaited with interest.

Systematic city planning, with an eye to both present and future needs, is one of the most notable features of the intense and growing interest in civic affairs now shown throughout the civilized world. It is only within the present century, and for the most part within the second five years of this decade, that much has been heard on the subject outside of Germany and isolated cities elsewhere. In the country last named, town planning along intelligent lines, combining both the practical and esthetic, as all intelligent town planning must do, has been in progress for a considerable time. In Great Britain, the town-planning movement has recently been given a great impetus by important parliamentary legislation, giving municipal authorities large powers to be exercised under the general direction of the Local Government Board. In the United States, interest in town planning has manifested itself in scores of cities chiefly through the efforts of voluntary civic organizations rather than municipal authorities, but in a few instances the cities themselves have taken the subject up in good earnest and are achieving noteworthy practical results. Particularly gratifying to the American workers in this field were the acknowledgments of American work made at the recent Town Planning Conference held in London, not long ago.

Elsewhere in this issue we give a brief account of the organization and intended work of a civic or municipal plans commission, created at Seattle, Wash., under the provisions of a recent amendment of the city charter. The fact that this commission has been authorized by popular vote and has recognition in the city charter gives reason to believe that its report and recommendations are more likely to be carried into effect than the plans formulated by some of the voluntary civic organizations in various parts of the country.

The Seattle commission is taking a broad view of its duties. It is looking ahead to a population of a million people, and looking far enough afield in every direction to include areas now beyond the city limits sufficient to accommodate so large a population and its various activities. The composition of the commission is also broad in scope, taking into account, as it does, all the various leading business, industrial and professional interests of the city.

The idea of planning city growth with a view to outlying areas is praiseworthy, and we shall look forward with interest to not only the scheme proposed by the commission, but also the extent to which it may be followed hereafter in actual development. It will be particularly interesting to learn whether it will be possible to extend the city plan into territory outside the city limits without actual consolidation with the city. Such extension might be possible through the cooperation of county authorities, but city and county authorities, when not identical, do not always work in harmony in the East, and we presume the same will be true in the West also.

Any one who has visited Seattle and noted how the major part of the city has been laid out on the old checker-board plan, entirely regardless of topography, cannot but regret that a city-planning commission was not created before the present atrocities were perpetrated. Few cities in the world lend themselves better to development of street plan on contour lines, rather than on the rectangular or gridiron system, than does Seattle. We have in mind particularly the hill-top residential sections of the city, with their unsurpassed views of the harbor, the two or three lakes within the city limits and the snow-capped mountains in the distance.

We note with pleasure that Seattle's very efficient City Engineer, Mr. R. H. Thomson, M. Am. Soc. C. E., is a member of the commission, and that the commission has retained Mr. Virgil G. Bogue, M. Am. Soc. C. E., of New York City, as expert adviser. We trust that the commission will not fail to retain, in addition, some one of the Americans who have recently come to the front as experts in the science and art of city planning. Thus far, few American engineers have had an opportunity, either through training or through the demands put upon them by municipalities, to develop the art of city planning in its broader aspects, and particularly not along either sociological or esthetic lines. Knowledge and experience of both building and landscape architecture are essential to the most successful city planning, as well as a somewhat intimate knowledge of the history and traditions of city development in its multifold phases, including, as we have suggested, the broad sociological or humanitarian aspects of the subject.

It seems safe to assume that the esthetic side will not be overlooked at Seattle, inasmuch as we understand that a few years ago the city, in conjunction with the University of Washington, called in an eminent firm of landscape architects to give advice regarding the development of an important section of the city.

In the Report of the Isthmian Canal Commission of 1899-1901, which made the original plans for the building by the United States of the Panama Canal, the following passage occurred in the paragraph relating to the Culebra cut:

> The entire cut will be lined with masonry walls finishing at Elevation 92, 2 ft. above high water, these walls having nearly vertical faces and furnishing benches 38 ft. wide on either side of the canal, on one of which the Panama Railroad will be laid, while it is probable that a service track will be placed on the other.

The International Commission of Engineers, which reported upon the plans of the canal three years later, was chiefly concerned with questions as to the type of canal to be built, whether with locks or at sea level, and such details as the cross-section of the Culebra cut and the protection of its sides were not considered in the report so far as we recall.

The Culebra cut is now well advanced toward completion and it becomes necessary to make decision as to whether retaining walls should be placed at the sides of the channel through the Culebra divide, as was proposed by the Board of ten years ago.

This question was recently referred by Col. Goethals to a board of engineers consisting of Col. Hodges, Col. Gaillard and Admiral Rousseau of the Canal Commission. Elsewhere in this issue we print the report of this board. It will be seen that the report is noncommittal. It states that the board considers it undesirable to attempt to put in revetment to protect the faces of the cut until the full depth of the cut has been reached. The question, therefore, whether the sides of the cut are eventually to be lined with retaining walls or not is still an open one.

The expenditure involved in building such retaining walls, should they be decided upon, will be a very considerable sum. Assume, for purposes of rough computation, that such walls would be 40 ft. in height, extending from the bottom of the canal to the water surface, with a base equal to half the height, or 20 ft., and with a thickness of 4 ft. at the top. To build such walls on both sides of the canal would require 188,300 cu. yds. of masonry per mile. Assuming even the low figure of $5 per cu. yd. for the masonry or concrete in these walls, the cost would be in the neighborhood of $1,000,000 per mile, or some $8,000,000 for the entire length of the channel through the Culebra divide.

It may be said that this is, after all, a trifling percentage of the total cost of the canal work, or of the cost of the Culebra section, but the more important question is whether these walls will really serve a useful purpose. In some locations, it is quite conceivable that the walls may be advantageous. Take, for example, a section where the depth of the cut is moderate and the material back of the wall which tends to flow in is on so moderate a slope that it is possible to construct a wall that will hold it. Under these conditions, it is conceivable that a dollar spent on retaining-wall construction may save the spending of two or three or four dollars in excavating material that might slide into the canal prism. Such locations, however, are not typical of the ordinary conditions through the Culebra cut. From a cursory inspection of the sides of the cut, it seems to us that at most places if the material on the slopes once started to slide into the canal it would slide in just the same whether a retaining wall were at the foot of the slope or not.

The fact is, of course, that in building a retaining wall to support an embankment or slope which is heavily surcharged, the engineer is dealing with forces which are unknown in magnitude, and which may, and often do, attain proportions that destroy the most substantial works that can be placed. An engineer of long experience who values his reputation would rather build something else than a retaining wall.

It is a common knowledge that a very considerable proportion of retaining walls eventually fail; and these failures are commonly taken as reflections upon the professional ability of the engineer who built them. This, however, in very many cases is unfair to the engineer. In the case of many retaining walls the factor of uncertainty as to the pressure which will develop against the wall is so great that the engineer ought not to be blamed if the wall failed. It is, in fact, not good engineering to build a retaining wall which is sure to stand any way. That is not the kind of wall or the kind of engineer that will make a dollar earn the most interest.

Returning to the question of putting walls at the sides of the Culebra cut, it is out of the question to build walls there which will surely stand. If the wall does stand in most places, the chances are that the slope behind it would stand anyway, without any wall. Further, if the wall does go over into the canal, it will make a very much more expensive wreck to dredge out than the stuff would which would have slid into the canal if the wall had not been there.

If it is decided to build the walls, then the cut

must be excavated that much wider to make room for the walls, and the cost of this extra excavation must be added to the cost of building the walls. As to what useful purpose the walls would serve after they were completed, we do not see that they could effect anything save to prevent a certain amount of material sliding into the canal from the slopes. But if the slopes do slide, after the walls are built, the material will land on the berme and will have to be hauled away by rail at a cost of perhaps 50 cts. to 75 cts. per cu. yd. On the other hand, if the walls are omitted and the same material slides into the canal, it can be dredged out and removed at a cost of perhaps 10 to 20 cts. per cu. yd. So far as appears, therefore, building retaining walls in the Culebra cut would appear to be even worse than a needless waste of money.

We should add, perhaps, that we intend no reflection on the able engineers on the Isthmian Canal Commission of 1901 by the above discussion. The paragraph relating to retaining walls which we quoted above from their report very probably was inserted with little consideration. The problems which that commission had to solve were larger than such details of the construction.

More than one engineer who has attended the conservation congresses of the past few years, or who has read the published proceedings of those meetings, has felt more or less disappointment because so little attention was devoted to the engineering aspects of conservation. A little reflection would show that in the early years, at least, of any society of propagandists more attention is almost sure to be given to matters calculated to create interest and to arouse enthusiasm than to constructive programs involving technical considerations. This has been particularly true of various other great American movements of the past dozen or twenty years, as exemplified in the national congresses designed to promote irrigation in the West and good roads everywhere and the improvement of rivers and harbors wherever a possibility for either exists.

It seems to us that in no great movement designed to interest the whole people has more recognition been given at the outset to engineers and other technical men than in connection with conservation. This was true of the first White House Conference on Conservation. A practice then arose, which has since been continued, of inviting technical societies to send representatives to each conference.

Elsewhere in this issue will be found portions of a report made to the Western Society of Civil Engineers by delegates sent from that organization to the St. Paul Conservation Conference of last September. In this report particular attention is called to the dominance of politics and oratory at the conference, with a relatively small amount of attention given to engineering and other technical matters. The authors of the report make a suggestion that is certainly worthy of careful consideration by engineers and engineering societies. They suggest that there be an engineering section formed in connection with future conservation conferences, and to this end that the various engineering societies of the country cooperate as best they may. It is further suggested that the program include a review of "the state of the art" in various divisions of conservation, such as water power, irrigation, swamp drainage, forestry and lumbering.

While we think the spirit of the suggestions will meet with general approval among engineers, we would call attention to the fact, already stated, that the chief work of these popular congresses must be, first, to arouse enthusiasm, and, second, to educate the people to the need of action. Technical discussion of all the subjects involved are already being carried on in various technical societies, and to be of value to technical men in or out of such societies they must for the most part be beyond the interest, if not the comprehension, of the general public. It must also be remembered that there is, as a rule, no lack of technical knowledge as to ways and means of carrying out conservation reforms. What is needed primarily is wise conservation legislation and efficient necessary administrative control of all that pertains to conservation by the nation, and the individual states and cities of the country.

While this is true it should be remembered that point would be given to the technical phases of conservation if they were discussed in connection with the great conservation congresses instead of in a wholly disassociated way. This has been true of one notable phase of conservation, namely, irrigation, which has been considered in what may be termed "engineering sections" of National Irrigation Congresses.

We cannot refrain from making critical reference to one of the specific subjects mentioned in the report under consideration; that is, the suggestion that in the proposed engineering section of future conservation congresses account be taken of "what our European brethren are doing in the way of fertilization from sewage." This topic is particularly well suited to illustrate the danger of going astray when technical subjects are discussed at popular conferences. The way in which this topic is presented in the report seems to indicate that the framers of the report were of the opinion that there is something to be learned in this country from agricultural utilization of sewage in Europe. We think a thoroughgoing review of "the state of the art" of sewage purification would show to engineers, as well as to laymen members of any conservation congress, that little, if anything, is to be expected from sewage utilization in America, except where it is employed to make up deficiencies in rainfall rather than in fertilizing value of the soil. This too-little-known fact, as we understand it to be, may be taken as an example of the possible value of having technical subjects thoroughly considered by technical men at conservation congresses, rather than presented in a superficial manner by laymen, or, possibly, by some poorly-informed engineer.

When Is the Double-Tracking of a Railway Justifiable as a Matter of Economy?

A correspondent of this journal raises a question which we doubt not has often been asked by railway officers, and which appears to deserve serious discussion. We print the substance of his letter as follows:

> In the operation of a single-track railroad system, which has a normal growing business, I am anxious to ascertain at what time does any zone or division of the road indicate that its operation as a single track is no longer economical. What reasons and what figures can be exhibited which would in themselves prove conclusively that as an economical proposition double tracking is justified, not sentimentally but strictly as a means for greater economy in operation?
>
> I am trying to get an idea as to what vital figures should be examined and what operating performances should be carefully noted that in themselves, without argument, form an economic reason which justifies the expenditure necessary to put in a double track.
>
> I have seen stray comments and references to this question, but I have never seen it thoroughly discussed.
>
> In such matters as grade revision, curve elimination and the like, there have been developed certain well defined rules which applied to the operation of any division demonstrate with reasonable accuracy the necessity and the justification of any such improvement. This is very fully touched upon by Messrs. Wellington, Berry and others; but a similar exposition and proof of the economic limit of single-track operation I have never seen carefully stated.
>
> Yours very truly,
> "Economist."
>
> New York, Nov. 11, 1910.

The question our correspondent asks is one by no means easy to answer. So far as we recall it has never been adequately discussed by any of the recognized authorities on railway economics.

Further than this, in the exact form in which the question is put above, it is doubtless impossible of answer. What our correspondent asks for is some rule or formula by which it can be shown that when the volume of traffic or the number of trains per day or per hour exceeds a certain amount, it will pay to doubletrack the line.

Not only is there no such rule, but there could not well be any such rule, because the circumstances of different railways are so widely different. Right at the start comes the question whether the main business of the railway is in freight traffic or passenger traffic. If it is passenger traffic, what sort of passenger traffic is it? In handling suburban passenger travel, for instance, the point is very soon reached where single-track operation involves delays, risks and limitations in train service that makes double-tracking essential, not only for economical train movement but to permit of a normal increase in traffic taking place. If the road is not double-tracked, its traffic will cease to grow.

On the other hand, when we get away from the cities to the railway lines carrying general freight and passenger traffic we find that an enormous traffic can be moved economically over single track roads. Mr. H. A. Delano, in a paper published in our issue of Dec. 29, says that some of the single-track railway lines in the West are handling traffic averaging 3,000,000 ton-miles per year per mile of line.

It will be apparent that the average train load is a most important factor in determining what volume of traffic can be economically handled before double-tracking is necessary. It is because American railways haul freight trains far heavier than those of any other country that single-track roads here handle a volume of traffic which would be impossible in any other country.

Again the character of the freight traffic makes a vast difference. A railway whose chief business is between its terminals with little local traffic between can handle an immense tonnage over a single-track compared with a road running through a densely settled district of New England or the Middle States where there is a populous town or city with heavy traffic to be taken care of every five or ten miles.

This indicates one reason why the typical railway lines of Europe, built in a country already densely populated, and with passenger traffic as their original aim, are generally double-track lines, while the typical railway lines of the United States, built originally as pioneer roads and with freight traffic as their main source of earnings, were nearly all single-track lines originally and have developed possibilities in the traffic capacity of single-track lines that were undreamed of a generation ago.

Again, when a railway finds a single track inadequate for a desired train service, double-tracking is not necessarily the alternative. In the case of a road through a thinly settled district, with stations a long way apart, the building of intermediate passing sidings is usually the first step to take care of an increased traffic. The next step often is to lengthen the passing sidings, so that a train can run some distance upon it; then this siding eventually forms part of the second track.

Still again, if double-tracking must be figured out on a basis of economy in operation, the rate of interest is a controlling factor. Over against the loss in time of rolling stock and train crews lying idle on sidings, plus the cost of wrecks traceable to overcrowded tracks, plus the loss of passenger traffic due to single-track delays, there is to be set the interest and maintenance and depreciation charges on the investment necessary to build the second track. It makes a large difference whether the bonds issued to build the double-track will bear interest at 3 or 4% like the bond issues of a dozen years ago or 5 to 6 per cent., which seems necessary to make a present-day bond issue salable.

So much for the difficulties in the way of giving a direct answer to our correspondent's question. But while there is not and cannot be any rule generally applicable to all railways by which to compute the limits of economical traffic capacity on single-track railways, it does not follow that one railway may not learn from another's experience. It would be useful and instructive to know what investigations and computations and estimates have been made in any given case to determine what savings would be made as a result of double-tracking, and how the results of experience have borne out the estimates.

We hope that this may meet the eye of some of our readers who may be acquainted with such

records and able to furnish them to us for publication. Such a result, we believe, would be the most useful answer to the question which our correspondent has brought forward.

Meeting Emergencies in Engineering Work.

To deal with emergencies is one of the frequent duties and trials of the engineer. There are probably few men of long experience in the profession who have not at some time been confronted with a problem calling for prompt decision and action to avert disaster. It may be the settling of a bridge pier, the slipping of a railway or reservoir embankment, the caving of a trench or tunnel, the washing out of falsework, the bursting of a pipe line or conduit, the wrecking of a bridge, the blocking of a railway by a landslide, the undermining of building foundations, or any one of a multitude of similar occurrences.

When warning comes suddenly and danger may be imminent, the first thing necessary is an instant analysis of the conditions, and a cool-headed decision as to the meaning of such warning or indication as may be given. Is a slight crack or displacement a matter of merely local settlement or movement, or is it an indication of impending collapse? Are any lives in danger? How can the truth be determined? What time is available for investigation or remedy? What methods of repair or reinforcement can be most readily and quickly applied? What has there been in the way the work has been carried out to throw light on the matter?

In many cases there is no warning. The engineer receives word that a pipe or conduit has burst and water is flooding property and endangering foundations; a filter plant treating polluted water is out of order; a pier or breakwater has been damaged by storm; a bridge has been wrecked by a steamer or a derailed train; a tunnel heading has caved, or a mine explosion has occurred. The man responsible for the work must be able to see at a glance the location and the conditions, and to plan immediate relief and future remedy in the face of confusion and possible danger or panic. He must consider what materials and men will be needed; where they can be obtained; how they can be most quickly got to to the scene of action; and what temporary relief can be afforded.

As an example, we may mention the wrecking of a railway bascule bridge by a steamer in Chicago, described in our issue of Feb. 3. Late on a Sunday afternoon in winter, the assistant engineer (the chief engineer being out of town) received word that the bridge was out of commission and both railway and river traffic were blocked. In spite of darkness and bad weather, steps had to be taken immediately to determine the extent of the damage and to devise means of repairing it. There was no time to study long over conditions or to discuss methods, or prepare detailed plans of the work. The damage being ascertained, the work of repair must be started at the earliest possible moment.

While many emergencies occur with little or no warning, there are others which do not demand instant action, though they may be equally serious with regard to possible developments. Some of these are what may be termed continuing emergencies, in which the engineer has a prolonged fight against the forces of nature or against conditions due to defects of construction. An instance of such an emergency is the slipping of material at a railway cut, such as were described in our issues of Nov. 21, 1907, and April 30, 1908. The slipping may appear first as a mere local disturbance of the slopes, necessitating piling and ditching, with constant watchfulness to prevent accident from the blocking of the track by sudden falls of material. The movement may increase in intensity until it extends to a considerable distance, with danger to buildings or other property. Similar cases are the driving of a tunnel through swelling material or material under high water pressure, such as the tunnels under the rivers at New York City, or the underpinning of a factory building whose foundations are settling at an alarming rate, as described in our issue of Oct. 6.

In addition to a readiness to comprehend and meet the conditions of an emergency, there is need for mechanical ingenuity to quickly devise methods and appliances for carrying on the work under adverse conditions. To improvise a makeshift splice for a broken bridge member, to rig up a toggle joint, to tighten a heavy chain wrapping, or numerous other details, may devolve upon the engineer. It is true that workmen and foremen are often very apt at such work, but they often fail to provide sufficient strength in their rigs. The engineer should be able to quickly apply to such practical work his knowledge of mechanics, of stresses, and of the strength of materials.

In some emergencies there is danger to be met. A mine explosion imprisons men down below and there is call for a rescuing gang. Workmen as a class are courageous and there is generally no lack of volunteers if a risky job must be tackled. The engineer, however, must decide whether he should permit men to go into danger, whether the emergency justifies the risk of human lives. Such a decision is one of the hardest tasks an engineer can face. He must not encourage or permit foolhardiness. He must not allow men under the impulse of excitement to sacrifice themselves in a magnificent but hopeless attempt to save victims of a mine accident, for example, who are beyond human help.

On the other hand, it is to be remembered that there is risk in daily work in the factory or the mine or the railway yard. It is proper to allow and encourage men to increase that risk when an emergency demands and justifies it.

The care of men is often important in emergency work when no risk of life is involved. A force is to be assembled to clear up a railway wreck, to fight a forest fire, to combat a flood. Men will work long and hard under such conditions, but they need and deserve the best provision possible to obtain in the way of food, shelter and special clothing. Such provision is one of the best evidences of executive ability that an engineer can furnish to the forces under him.

How may an engineer fit himself to meet emergencies? From one point of view a technical education can do little. The illiterate foreman of a bridge erecting gang has an education which the college graduate as he receives his diploma does not possess. Nevertheless, the college graduate has the foundation (or should have it) on which engineering knowledge rests, and if he has naturally as clear a head and as sound a judgment as the foreman, he may be some day the better man to handle an emergency.

The engineer should have the broader grasp of a situation. He should have not only the practical knowledge of bridges which the erection foreman possesses but a general knowledge of engineering besides. This general knowledge should help him to cope with an unprecedented situation, where the foreman might be quite uncertain of himself. The engineer's technical education should at least have taught him how to think clearly and how to analyze a problem with accuracy and certainty. We are assuming, of course, that the student had a mind, to start with, able to receive such training. There are many men who are naturally slow of thought, uncertain of themselves, timid in dealing with others. Such men cannot be made successful leaders in an emergency by any sort of technical training.

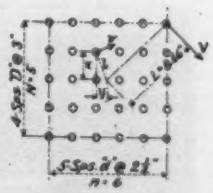

Fig. 1.

Assuming, however, that the young engineer has it in him to make good, he can cultivate the habit of prompt decision. He can learn, by observation and by reading the records of accidents, how others deal with emergencies. He can, as responsibility is placed upon him, seek to discharge that responsibility in the most perfect manner. He can train himself to keep cool.

The weak point of many men in meeting emergencies is that they become excited and attempt to rush so fast that they miss some essential matter. It is the man who keeps his nerve, who thinks rapidly but clearly, who issues definite orders to each subordinate and imbues them with his own calmness and courage—such a man can best handle an emergency.

LETTERS TO THE EDITOR.

Obtaining the Moment Value of a Group of Rivets.

Sir: The stress on each rivet in a group of rivets subjected to a moment only, is proportional to the distance of the rivet from the center of gravity of the group, and its moment value is proportional to the square of the distance. Let V = the allowable value of stress on the outermost (most highly stressed) rivet, distant L from the center of gravity of the group. (See Fig. 1.) Then the stress v on any other rivet distant l from the c. of g. of the group will be $\frac{V}{L} l$, and its moment value will be $\frac{V}{L} l^2$. For the whole group the moment value will be the sum of the moments of all of the rivets or,

$$\frac{V}{L} \Sigma\, l^2 = \frac{V}{L} \Sigma\, (x^2 + y^2) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Assume a rectangular group of rivets.

Let D = the uniform spacing vertically.

N = the number of rivets in each vertical row.

d = the uniform spacing horizontally.

n = the number of rivets in each horizontal row.

For an arrangement as shown in Fig. 1, eq.(1) will then become,

$$\text{Moment} = \frac{V}{L} [2\, n\, D^2\, (1^2 + 2^2 + \ldots.) + \frac{N\, d^2}{2}\, (1 + 3^2 + 5^2 + \ldots.)]$$

Summing the two series in the above equation, bearing in mind that the number of terms in the first series is $\frac{N-1}{2}$, and in the second series is $\frac{n}{2}$, and then reducing, we will find the

$$\text{moment} = \frac{V\, n\, N}{12\, L} [D^2\, (N^2 - 4) + d^2\, (n^2 - 1)] \ldots\ldots\ldots (2)$$

For example, take the group of rivets shown in Fig. 1; six vertical rows of five rivets each spaced 3 ins. vertically and 2½ ins. horizontally. Allow 5,000 lbs. on the outermost (most highly stressed) rivet. The moment value of the group will be

$$\frac{5{,}000 \times 6 \times 5}{12 \times 8.66} [3^2 \times 24 + (2\tfrac{1}{2})^2 \times 35] = 627{,}000 \text{ in.-lbs.}$$

For a single row of rivets $n = 1$ and $L = \frac{D(N-1)}{2}$ and eq. (2) becomes, moment $= \frac{V\, D\, N}{6} (N + 1)$. Thus for one vertical row of five rivets spaced 3 ins.,

$$\text{moment} = \frac{5{,}000 \times 3 \times 5 \times 6}{6} = 75{,}000 \text{ in.-lbs.}$$

Now note in eq. (1) that the first member is an expression for polar moment of inertia before passing to the limit, which is equal to the sum of the moments of inertia about two rectangular axes through the pole. By this principle we can obtain approximately the moment value of a group of rivets of any regular shape as, for example, the triangular group shown in Fig. 2. Assume the value of the stress carrying the moment to vary uniformly over the whole triangle instead of from rivet to rivet. The stress per sq. in. of this area at unit distance from the origin will then be

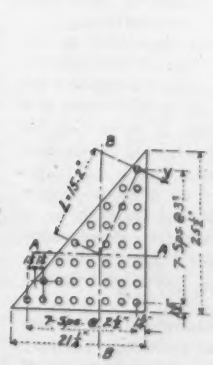

Fig. 2.

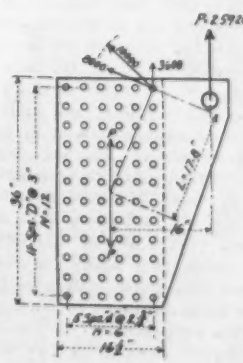

Fig. 3.

$$\frac{\text{number of rivets} \times \text{allowable value one rivet}}{\text{area of triangle} \times \text{distance to outer rivet}} = \frac{36 \times 5{,}000}{25\tfrac{1}{2} \times 21\tfrac{1}{4} \times \tfrac{1}{2} \times 15.17} = 43.9 \text{ lbs.}$$

The polar moment of inertia of the triangle about its center of gravity is the sum of the moments of inertia about the pair of rectangular axes $A\ A$ and $B\ B$ passing through c. of g.,

$$= \frac{21\frac{1}{4} \times (25\frac{1}{2})^3}{36} + \frac{(21\frac{1}{4})^3 \times 25\frac{1}{2}}{36} = 16{,}400 \text{ ins.}^4,$$

and the moment value of the group of rivets will be 43.9 × 16,400 = 719,000 in.-lbs.

By the ordinary method (a tedious process) of finding the sum of the squares of the distances of all the rivets from the center of gravity of the group and multiplying this value by the allowable stress on the extreme rivet divided by its distance from the c. of g., the moment found is, exactly, 708,000 in.-lbs. The error, then, by the approximate method is for this particular case, 1½%.

The application of the methods explained above will be shown by an example such as has occurred in actual practice. Assume rivets at 10,000 lbs. (double shear). In Fig. 3 the *direct* stress on each rivet due to the load $P = \frac{259{,}200}{72} = 3{,}600$ lbs. For the rivet most severely stressed by the direct stress and the moment due to P, combined, there will be available a component of 8,000 lbs. to resist moment, as shown. Apply eq. (2). The full moment of the group $= \frac{8{,}000 \times 6 \times 12}{12 \times 17.8} [3^2 \times 143 + (2\frac{3}{4})^2 \times 35] = 4{,}170{,}000$ in-lbs., while the moment to be resisted is 259,200 × 16 = 4,147,000 in.-lbs. So the connection as shown is safe.

By the approximate method, the moment-stress on the rectangle per sq. in. at unit distance from the center of gravity of the group $= \frac{8{,}000 \times 72}{36 \times 16\frac{1}{2} \times 17.8} = 54.4$ lbs. The polar moment of inertia of the rectangle

$$= \frac{16\frac{1}{2} \times (36)^3}{12} + \frac{36 \times (16\frac{1}{2})^3}{12}$$

= 77,600, and the moment value of the group will be 54.4 × 77,600 = 4,210,000 in.-lbs., a slightly larger value than before.

For convenience the polar moments of inertia of a few figures are given below:

Triangle, base b, height h	:	$\frac{b\,h}{36}(b^2 + h^2)$
Rectangle, base b, height h	:	$\frac{b\,h}{12}(b^2 + h^2)$
Circle, radius r	:	$\frac{\pi r^4}{2}$
Ellipse, semi-axes a and b	:	$\frac{\pi a b}{4}(a^2 + b^2)$

A. G. Hayden.
60 N. Allen St., Albany, N. Y., Nov. 25, 1910.

Gasoline Locomotives for Construction Work and Industrial Railways.

For the operation of industrial railways at manufacturing plants and on contracting or general construction work the use of gasoline locomotives presents many advantages. These advantages are particularly in economical operation, convenience and handiness; the machine is ready for use at any time, its cost of maintenance and repair is small, it requires a minimum amount of labor and skill in handling, there are few places where fuel is not readily obtainable, and when not in use it involves no continued expense for fuel. This last feature is specially important where the use of the engine is intermittent.

Gasoline locomotives are the specialty of the Milwaukee Locomotive Mfg. Co., of Milwaukee, Wis., and a number of this company's engines are now in use. They are built of various sizes and for any gage of track, in order to meet varying requirements. All are four-wheeled machines, with chain drive to both axles. The truck frame is a heavy casting in order to give necessary weight for adhesion, and all the framing is of steel, with a strong and substantial construction to stand hard usage on rough tracks. The engines will work with gasoline, kerosene, oil distillate, naphtha or alcohol.

The arrangement of the machinery equipment is shown in Fig. 1. A four-cylinder, vertical, water-jacketed engine is used, having its shaft (which has five bearings) placed parallel with the track. The engine is equipped with a governor connected to the carburetor for automatically controlling the proportions of air and gasoline in the charge. The hub of the flywheel on the end of the crank shaft has a socket to receive the end of a shaft which carries two cones and bevel pinions. This shaft can be moved endways by means of a hand lever or pneumatic device in the cab, so as to bring one or other of the pinions in mesh with a bevel wheel on a transverse shaft carrying part of a train of gearing. In this way the locomotive can be driven forward or backward as required. The gearing is made to give from one to three rates of speed, according to the size of the engine; the changes are made by jaw clutches, with all gears in mesh. The gears run in oil in a cast steel gear box. The power is transmitted to the axles by means of roller driving chains on sprocket wheels; the rollers (which form the cross bars of the links) are case-hardened to ensure a minimum rate of wear.

The cooling water is circulated by a geared pump, and the radiator has capacity for sufficient water to keep the engine from overheating when worked continuously under full load. The gasoline is stored in a seamless drawn-steel tank. The equipment includes an automatic oiling system, a magnet and dry-cell battery ignition, brakes, couplers (of the M. C. B. type when railway cars are to be handled), a rail sanding jet and a whistle. The larger locomotives have a 7-HP. engine with device for starting the main engine; also a compressor for air brakes and for pneumatic controlling devices for operating the main and transmission clutches. The fuel consumption is said not to exceed 0.1-gal. per brake-HP.-hour with gasoline or distillate, and 0.125-gal. with alcohol or kerosene. The expense for fuel for eight hours' run of a 50-HP. engine is given as $2.40. The total expense would be about $7.90, including fuel, wages of operator, lubricating oil, maintenance, depreciation and interest on investment.

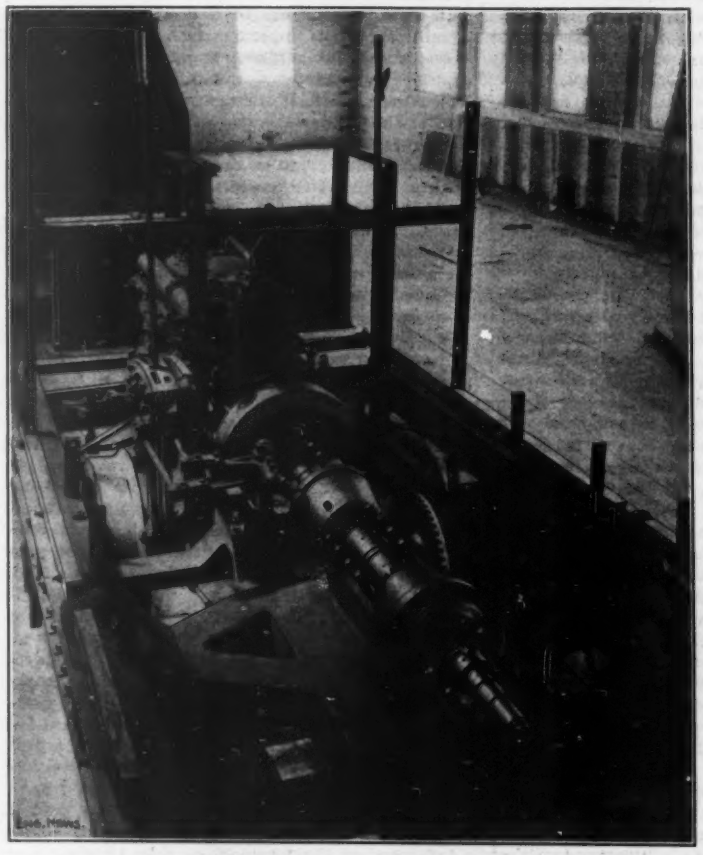

FIG. 1. ENGINE AND GEARING OF GASOLINE LOCOMOTIVE.
(Milwaukee Locomotive Mfg. Co., Milwaukee, Wis.)

The ordinary machines have a cab at the middle of the frame, with a chamber at each end enclosing parts of the equipment. These range from 15 to 150 HP., with weights of 2½ to 25 tons. The smallest machines are 8 × 4 ft., 8 ft. high, with 18-in. wheels; they can haul 20 tons on the level or 5 tons on a 3% grade. The 16-ton 100-HP. machine is 20 × 7½ ft., 11½ ft. high, and has 36-in. wheels. It has a speed range of 4 to 40 m. p. h.; at the latter speed it can haul 11 tons on the level, but at 8 m. p. h. it can haul 100 tons on the level or 24 tons on a 3% grade.

For use in mines, special low engines are used, with the operator sitting at one end. These are 8 ft. long, 10 ins. wider than the gage of track, and 45 ins. high; they weigh 3½ tons and 5 tons, with engines of 25 and 35 HP. The larger machine is said to be capable of hauling 43 tons on the level at 4 m. p. h. (38 tons at 8 m. p. h.), or 11 tons on a 3% grade. To avoid trouble from fouling the air in mines by the exhaust gases, the exhaust is delivered into a tank containing trays filled with a lime or chemical solution; the gases circulate between these trays. One of the 35-HP. mine locomotives used for outdoor work is shown in Fig. 2. This is used by the Standard Brick Co., of Milwaukee, in handling clay brick from the pits to the mill.

Fig. 3 shows a 100-HP., 20-ton locomotive built for the Mt. McKay & Kakabeka Falls Ry., of Fort William (Ont.), Canada. This large machine has automatic air brakes, air-controlled devices for operating the clutches, and a 7-HP. auxiliary engine with device for starting the main engine. Two locomotives are used for handling lumber in the yards of the Sierra Nevada Wood & Lumber Co., at Hobart Mills, Cal. Another is used by the Wolverine Portland Cement Co. for hauling material 1¼ miles

FIG. 2. GASOLINE LOCOMOTIVE OF 35 HP. HAULING CLAY FOR A BRICK MAKING PLANT.

from the quarries to the mills at Coldwater, Mich. The Westinghouse Air Brake Co. has a gasoline locomotive for hauling railway cars at its works; the Postel Milling Co., of Mascoutah, Ill., uses for similar work a 12-ton 75-HP. locomotive. This is found to be a very handy and economical method of handling freight cars at industrial and manufacturing plants. Another field for the use of these gasoline engines is on railway and other construction work, operating on ordinary or portable tracks. The Milwaukee Electric Ry. & Light Co. has used one to haul a tower car in stringing wires on new electric lines.

That there is a field for and a demand for locomotives of this sort is indicated by developments both in this country and abroad. A number of engines of various designs have been built by different makers, and used to some extent; some of these have been noted in our columns. But in most of these cases (with the exception of the Milwaukee Locomotive Mfg. Co.) the engines have been taken up as a side issue to other business, and very little has been done towards introducing the engines commercially. One design was brought out a few years ago by the Termaat & Monaghan Co., of Oshkosh, Wis., but the manufacture was discontinued as being outside the line of the company's work. The engine as built was a 3-ton four-wheel machine having the wheels connected by coupling rods, and the front wheels driven by rods from a countershaft. This machine hauled stone and gravel from a quarry in 3-yd. dump cars. The track had a gage of 36 ins. and a maximum grade of 4%. The speed was from 3 to 4 m. p. h. A 1-ton gasoline locomotive has been used on road construction work by the New York State Highway Commission; this hauled stone from the quarries, and worked on grades as steep as 4%.

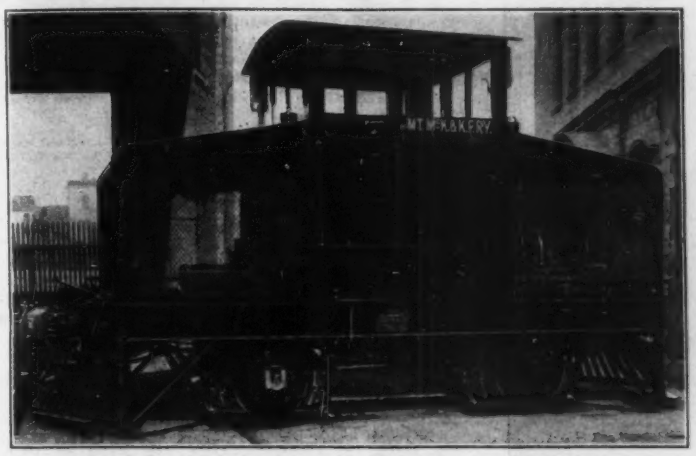

FIG. 3. GASOLINE LOCOMOTIVE OF 100 HP.
(Milwaukee Locomotive Mfg. Co., Milwaukee, Wis.)

A mine locomotive built by Ironside & Dyckerhoff, of London (England), is operated by a 12-HP. single-cylinder kerosene engine, and is said to have a fuel consumption of 0.6-pint per HP.-hour at full load. A gasoline motor car (designed to haul two trail cars) has been built by J. W. Brooke & Co., of Lowestoft (England), for a branch railway in the Argentine Republic. This has a 50-HP. four-cylinder engine (5½ × 6 ins.). Another example is a 10-ton engine built by McEwan, Pratt & Co., of London, England, for switching service on the lines of the Assam Oil Co. (India). This is a six-wheel machine, with all wheels coupled, of 5½ ft. gage and 5½ ft. wheelbase. It has a four-cylinder engine developing 50 HP. at 900 r. p. m.; this is geared to a countershaft from which driving chains are led to the front axle, a spring connection taking up the shock in starting. The engine has two speeds, and is designed to haul 67 tons at 10 m. p. h. on the level or at 4½ m. p. h. on a grade of 1.2%. When developing 50 HP. (900 r. p. m.) the fuel consumption is said to be 3½ gals. per hour, or 0.56-pint per brake HP. per hour.

A railway inspection car operated by a paraffine engine has been built by Charles Price & Son, of Manchester, England. The car has three cross seats (with reversible backs), and is operated from either end. Under the middle seat is placed the engine, having four cylinders 4 × 5 ins., and developing 20 HP. at 100 r.p.m. Its shaft is transverse to the track, and gears provide for speeds of 12, 24 and 40 m.p.h. From the lower gear shaft, power is transmitted to one of the axles by a Renold silent chain. The car is mounted on four-cast-steel 38-in. wheels, with a wheelbase of 8 ft. Its weight is about 3 tons.

A Report by a Geologist on Slides in Culebra Cut and by a Board of Engineers on the Revetment of the Sides of the Cut.

On Nov. 15 a report on the slides which have taken place in Culebra Cut was presented by Dr. C. W. Hayes, Chief Geologist of the U. S. Geological Survey. A report has also been presented by a Board of Engineers on the proposed revetment of the sides of the cut. We reprint below, from the "Canal Record" of Dec. 7, the major part of these two reports.

Report of the Geologist.

Section of Canal Affected

The practicable side slope depends on (1) depth of excavation; (2) character of materials, and (3) geological structure. Examination of the Cut indicates that serious difficulty through failure of slopes will be experienced only in the section between Empire and Pedro Miguel, or between stations 1720 and 1880. Small slides occur outside of this section, as at La Pita, but they are due to exceptional conditions and will be relatively unimportant.

Character of Materials.

Within the section defined above occur four distinct classes of materials in excavation, viz.:

1. *Sedimentary Rocks.*—This class includes: (*a*) volcanic agglomerates composed wholly of material ejected from volcanoes in the form of angular fragments varying in size from the finest dust to several inches in diameter; deposited in water, but very imperfectly bedded; generally bluish green in color; moderately hard when first exposed, but crumbling rapidly in contact with the air.

(*b*) Fine grained clays; blue, red or black; composed largely of fine volcanic dust, which has been transported and deposited by water, and is, therefore, well bedded; like the agglomerate, moderately hard when first exposed, but crumbling even more rapidly in contact with the air.

(*c*) Lignitic coal or black carbonaceous clay; beds, 1 to 3 ft. thick, interstratified with the red and blue clays of (*b*).

These beds—(*a*), (*b*) and (*c*)—with some unimportant sandstones and limestones constitute the Culebra formation of tertiary age.

2. *Intrusive Igneous Rocks.*—These are chiefly large masses of dark colored andesitic rock, which have been forced upward into the sedimentary beds, in some cases in a fluid condition, but more generally after having solidified. The intrusion was accompanied by tilting and crushing of the previously horizontal sedimentary beds. The andesite is generally intersected by numerous joints, but does not disintegrate readily on exposure, and where supported below will stand in vertical slopes. Gold Hill and Contractor's Hill are examples of these andesitic intrusive masses. All the other high hills in the Culebra section of the Zone are apparently due to the presence of similar rocks.

3. *Lava Flows.*—A flow of light gray trachytic lava, 20 to 30 ft. thick, occurs conformably interbedded with the Culebra clays throughout the central portion of the Cut. Its relations are exactly those of a sedimentary bed. The trachyte does not disintegrate readily, but by reason of its abundant joints it does not afford any support to the clays above.

4. *Residual Clays.*—All the rocks in this region are more or less deeply weathered and the original surface is everywhere covered with a residual deposit, generally clay, dark red in its upper portions and varying shades of red and yellow below. This clay is derived directly from the rocks on which it rests, and is thinnest over the intrusive andesites, because they decay less rapidly than the sedimentary rocks. It is thickest over those portions of the sedimentary rocks which have been so fractured as to permit the easy percolation of surface waters. It is usually separated from the underlying unweathered rock by sharp line, indicated by an abrupt change in color and texture.

Failure of Side Slopes

The original 3 on 2 slopes have failed to stand at numerous points. Varying conditions have given rise to three classes of failures which may be designated (1) surface flows; (2) structural breaks, and (3) surface disintegration.

1. *Surface Flows.*—Wherever the residual clay described above rests upon an inclined rock surface and the lateral support of the mass is removed, as is done when a trench is excavated, the portion of the mass lying above the unsupported side tends to flow down the sloping surface. The material has no cohesion within itself and very slight adhesion to the underlying rock. It acts like a viscous fluid and may flow on slopes as low as 1 on 7 or 8. Having started as a purely surface flow, it may gather sufficient momentum to carry down portions of the underlying unweathered rock, particularly if the latter has previously been deeply fractured. The Cucaracha and Paraiso slides are of this type. Between Gold Hill and Paraiso, a series of andesitic intrusions, east of the Canal, have given the sedimentary beds a westerly dip. They form a series of troughs pitching down toward the Canal. Moreover, the sedimentary beds, in addition to being tilted, have been deeply fractured and "slickensided," so that their cohesion is greatly reduced and the movement which started in the surface clays has extended some distance below the base of the clays and involved the underlying unweathered rock.

2. *Structural Breaks.*—Every variety of rock has a limiting strength, and if loaded beyond this limit will be crushed or will flow. The crushing strength varies between very wide limits, and is always lowered when one or more sides of the block are unsupported laterally. The weakest member in the sedimentary series occurring in the Culebra Cut is the lignite, or lignitic clay. When the lateral support is removed from a lignite bed it tends to give way under the weight of the overlying rocks and a slide results. The same result may occur even if the weak bed is not cut through, but merely unloaded by excavating down nearly to it. In this case it flows out from under the load and bulges up in the excavation. This type of slide has occurred at various points between Empire and Gold Hill, and in nearly every case the immediate cause appears to be the failure of a lignite bed under the unbalanced pressure due to the excavation.

This type appears to offer more serious difficulties than the surface flows, and the obvious prevention is in making the slopes sufficiently low so that the weakest rock subjected in the unbalanced pressure shall not be loaded beyond the limit of its crushing strength. It seems reasonably certain that in the section of the Canal threatened by slides of this type less material will have to be removed if the slopes are lowered before the break occurs than afterwards.

3. *Surface Disintegration.*—As previously stated, all the sedimentary rocks of this region tend to disintegrate very rapidly when exposed to the air. They first crumble into small angular fragments and eventually into the finest powder. Slopes cut in such rocks will rapidly disintegrate and crumble until they reach an angle on which the products of disintegration will lie and form a protective mantle. Vegetation will, of course, greatly assist in this protection. While the failure of the Canal slopes from this cause will not be a serious matter, it will involve the removal of a large amount of material in the aggregate, and constant attention for a long time.

Under certain conditions this surface disintegration becomes a more serious matter. For example, the contact between the intrusive andesite of Contractor's Hill and the sedimentary clays dips away from the Canal at an angle of 55°. The crumbling of the clays below the contact leaves the andesite mass overhanging, and the overhang will increase as the Canal is carried to its full depth and more clay is exposed. With a rock so much fractured as the andesite, this condition is unsafe and the exposed surface of the underlying clay should, therefore, be protected from further disintegration.

Recommendations

1. A competent geologist should be employed on the Isthmus until the Canal is completed.

2. The geologist should continue the record of geologic facts, as revealed by the excavation, constructing a series of accurate cross-sections. The work already done along this line by Messrs. Nichols and Raggi is extremely valuable, and their zeal and intelligence cannot be too highly commended.

3. Additional core drill records should be obtained under the direction of the geologist, particularly to determine whether or not sedimentary beds of exceptional weakness occur in such position as to cause landslides of the structural break type.

4. The geologist should afford assistance to the engineers in determining the most economical slope for each section of the Canal, and the slope should be fixed, not arbitrarily, but in view of the known geologic conditions.

Recommendations of Board on Revetment and Retaining Walls.

The board appointed to determine, so far as present conditions permit, whether the faces of Culebra Cut should be revetted or protected by grouted rubble or concrete facings has submitted the following recommendations, which have been approved:

(1) The board is of the opinion that it is undesirable to attempt, under ordinary circumstances, to put in revetment for the purpose of protecting the faces of the Cut until the full depth of the Cut has been reached.

(2) For the reason just stated, the board believes that unless something unforeseen should occur, there is no necessity, nor is it advisable, to begin any revetment work, properly so-called, during the following dry season.

(3) The board is of the opinion that the preservation of a maintenance track on the east berm of the Canal is eminently desirable, if this result can be accomplished at a reasonable cost, and believes that the progress of the work up to the present time has not shown conclusively that such a track cannot be maintained without undue expense. The board, however, is unwilling to enter at the present time upon a policy which, in order to maintain the berm, might involve a large expenditure before the possibility of such maintenance shall be conclusively established. For this reason, it believes that during the next dry season the construction of retaining walls, or other supports, to the berm should be limited to situations where such support is necessary for construction purposes, and finds, as the result of the inspection already described, but a single locality where it is prepared to recommend that measures be taken during the next dry season to support the berm, to wit.:

That portion of the 95-ft. level on the east side of the Canal, between stations 1870 and 1880, at the foot of the old Paraiso slide, where it believes that construction work requires the preservation of the track on the 95-ft. level.

(4) The excavation has not yet reached the full depth at the point just mentioned, and the board suggests the following treatment for this locality, to wit.:

That after the dry season has set in a cut be made to full depth, or perhaps a little deeper than the bottom of the Canal, along the front of the unstable bank, extending into the bank outside of the side slope of the Canal, a distance sufficient to form the foundations for a retaining wall or support, the actual distance of the cut into the bank being determined by the manner in which the bank acts when the cut is being made. If the face of the bank remains reasonably stable and does not slide into the Cut, it may be possible to take out two shovel cuts before building the support. If so, the support may be constructed of riprap stone, with a dry facing, and probably without the use of concrete or mortar. If, on the other hand, the bank shows signs of moving when the first shovel cut is taken, a concrete retaining wall, back filled with dry rubble, will probably better meet the situation. The length of bank requiring this treatment is about 900 ft.

The board making the report consisted of Lieut.-Col. H. F. Hodges, Lieut.-Col. D. D. Gaillard and Civil Engineer (U. S. N.) H. H. Rousseau.

A Large Steel Six-Sheave Pulley Block.

The accompanying cut shows one of the largest pulley blocks ever constructed. It is one of two recently completed by the W. W. Patterson Co., of Pittsburg, Pa., for the Seaboard Construction Co., of Philadelphia. The safe working load of these two blocks is 125 tons. They were built especially strong so that a standard triple block could be attached to the bottom of each six-sheave block, giving the same working effect as two nine-sheave blocks. This measure was necessary because of the extra power required by a short mast of 20 ft. and a long boom of 50 ft. The blocks are to be used for the upper lift of a large derrick car, designed especially to handle 50-ton loads.

All the plates in the blocks are of ½-in. steel. The side straps are 8-in. × ¾-in.; the head pin is 4⅛ ins. in diameter, and the sheave pin 3 ins. The bottom bolt to which the triple block is attached is 2½ ins. in diameter. The sheaves are grooved for ⅞-in. plow steel wire cable. Each block weighs 1,804 lbs. There are no shackles for the blocks as they are attached directly to the derrick by 4½-in. pins.

A large wooden sheave block made by the same manufacturer was described in Engineering News of Mar. 21, 1907.

Sanitary Survey of the Ohio River in Pennsylvania.*

By SAMUEL G. DIXON,† and F. HERBERT SNOW.‡

The upper Ohio River is an important resource to the country through which it flows no less than it is a resource to the states of Ohio, West Virginia and Kentucky and Indiana commercially and as a source of domestic and industrial water-supply.

Appropriations have been made by Congress which assure a completion of a succession of locks and dams in the river which will render the river navigable during periods of least flow. Committees of the Chamber of Commerce of Pittsburg are engaged in studying the problem of flood prevention and control at Pittsburg. Ways and means are being considered for regulating the flow of the Allegheny and Monongahela rivers which, if adopted and put into force, will, to a material degree, improve the quality of the waters of the Ohio River in Pennsylvania. Commercially and industrially such works will prove of inestimable value. However, to conserve the purity and potability of the waters of the Ohio River for the protection of public health, other public works will be necessary.

Early in the history of the administration of the new laws of Pennsylvania pertaining to public health, the Commissioner of Health inaugurated surveys of the Allegheny and Monongahela river basins and of the Ohio River basin within Pennsylvania and subsequently

A Steel Pulley Block Weighing 1804 lbs. Made by the W. W. Patterson Co., of Pittsburg.

by unanimous agreement of the Governor, Attorney General and Commissioner of Health, decrees relative to the adoption of sewerage systems and sewage-purification works were issued to a majority of the municipalities in said basins. The city of Pittsburg appropriated $40,000 to defray the cost of designing a comprehensive system of intercepting sewers and sewage-disposal works. Upwards of thirty municipalities adjacent to the city of Pittsburg have adopted improved sewerage systems or are preparing plans therefor and for the treatment of their sewage in compliance with the terms of decrees issued by the Commissioner of Health to them. All of the important towns along the Ohio River in Pennsylvania have also been ordered to prepare plans contemplating the ultimate discontinuance of the discharge of sewage into the river or its tributaries. These streams are now used for domestic or industrial purposes and this use must increase as time goes by.

It is all important in the interests of public health and for the material well being of the district that no more sewage be discharged into these waters than is now discharged; and, furthermore, that ultimately as much sewage as practicable shall be treated and purified before the water, which is made the vehicle for transporting these poisons from the vicinity of habitations and industrial plants, reaches the river.

It has been determined by the Legislature of Pennsylvania to be essential to the interests of public health that sewage shall cease to be discharged into waters used subsequently as sources of public water-supply. In the administration of this law, there are many practical factors which must be taken into consideration and which obtain to a material degree, and it must necessarily be a matter of many years before the sewage of all municipalities along the Allegheny, Monongahela and Ohio rivers ceases to be discharged untreated into these streams, but progress towards this end is made each year in Pennsylvania.

The Allegheny River has been selected by the city of Pittsburg as the permanent source of water-supply to its inhabitants. This city is growing naturally and by annexation and the time may not be far distant when the chain of communities along the banks of the rivers mentioned and with a radius of many miles from the forks of the Ohio River will be consolidated into one municipality and have one source of supply, namely, the Allegheny River.

The State Commissioner of Health has considered a policy with respect to the conservation of the purity and potability of the waters of the Allegheny which may not obtain with respect to the towns along the Monongahela and Ohio rivers, and it must be evident to every student of sanitation and municipal hygiene that a greater pollution of the Ohio River than now exists would be prejudicial to public health and also that the interests of public health will be subserved by diminishing the pollution of the Ohio River.

There is a constitutional limit of municipal indebtedness in Pennsylvania which retards, in some cases, the immediate installation of sewage-purification works. All work in the way of the building of sewers or of disposing of the sewage of the towns of the state must be done in conformity with a comprehensive plan approved by the Governor, Attorney General and the Commissioner of Health, which plan ultimately involves the treatment and purification of the sewage.

It is not necessary to have additional legislation in Pennsylvania except possibly such enabling acts as municipal corporations may require to facilitate the erection and maintenance of sanitary improvements.

A joint resolution was adopted by the Ohio Legislature on April 29, 1908. [Its substance, as expressed by its title, was] as follows.

Providing for a commission to recommend measures to prevent the pollution of the Ohio River, and requesting the Legislatures of the States of Pennsylvania, West Virginia, Indiana and Kentucky to cooperate by appointing similar commissions.

Since under the laws of Pennsylvania everything is done that can be done in reason to bring about the discontinuance of the discharge of sewage into the Ohio River, it was decided by the Governor of Pennsylvania that there was no need for the appointment of a commission in that state and that the Commissioner of Health could better represent the commonwealth in meeting with any commissions which may be appointed by the Governors of the other states mentioned in the joint resolutions.

Two conferences of the Joint Ohio River Sanitary Commission have been held, the first at Wheeling, W. Va., the second at Columbus, Ohio, the states of Pennsylvania, Ohio, Indiana, West Virginia and Kentucky being represented. It was decided that a preliminary sanitary survey of the Ohio River from Pittsburg to the Ohio state line should be made by Pennsylvania and that the states of Ohio and West Virginia should conduct a general survey of the river bordering their respective territories.

Typhoid Fever in Pittsburg.

The city of Pittsburg proper includes the old city and the north and south side. The old city comprises the land between the Allegheny and Monongahela rivers at their confluence. The south side comprises the wards on the south bank of the Monongahela. The north side is land formerly comprising the territory of Allegheny City now annexed to Pittsburg. For many years the old city and the south side comprised the municipality of Pittsburg. Prior to the last part of 1907 raw Allegheny River water was supplied to Pittsburg in the forks of the old city. On Dec. 19 of that year partially filtered water was introduced into the old city. The volume of filtered water was constantly increased during 1908, until on Oct. 3 of the year, all of the old city was supplied with filtered water. The south side continued to receive raw Monongahela water until 1909, when filtered water was introduced. The north side continues to receive raw Allegheny River water.

In the following table the actual typhoid fever deaths in the old city on the south side, excluding Allegheny City, are given:

Year.	Deaths.
1900	464
1901	416
1902	475
1903	474
1904	503
1905	380
1906	519
1907	502
1908	186
1909	63
1910	22 for 4 months.

The average number of deaths from typhoid fever for the years 1900 to 1907 inclusive was 466. For the year 1909, there were 63 deaths only from the disease for the old city and south side. This is a reduction in deaths from typhoid fever of 85⅞.

*Slightly condensed from conclusion of a report to the Joint Ohio River Sanitary Commission.

†State Commissioner of Health, Harrisburg, Pa.

‡Chief Engineer, State Department of Health, Harrisburg, Pa.

On or before Dec. 1, 1911, the city is to prepare a comprehensive sewerage plan for the collection and disposal of all of the municipal sewage by some modern method of treatment.

Typhoid Fever in Ohio River Towns in Pennsylvania.

In the following table appears the typhoid fever death record for the year 1906 to 1909, inclusive, in the incorporated municipalities located on the banks of the Ohio River in Pennsylvania below Pittsburg and the estimated population of these places;

Municipality.	1906.	1907.	1908.	1909.	Population.
McKees Rocks	11	10	3	3	10,000
Bellevue	7	2	0	3	8,300
Avalon	1	2	1	2	6,000
Ben Avon	2	0	0	2	2,000
Emsworth	0	0	0	1	2,000
Glenfield	0	0	0	0	1,000
Coraopolis	0	2	0	0	5,400
Haysville	0	0	1	0	200
Osborne	0	0	0	0	500
Sewickley	2	1	0	1	4,500
Edgeworth	0	0	0	0	1,500
Leetsdale	1	0	0	0	2,300
Ambridge	4	2	0	0	5,000
Woodlawn	..	..	..	0	3,500
Aliquippa	0	0	1	0	1,200
Baden	1	0	0	0	700
Conway	0	1	1	1	1,000
Freedom	1	3	1	0	2,700
East Rochester	0	..	..	..	700
Monaca	2	0	1	0	3,500
Rochester	9	15	6	8	5,000
Beaver	0	0	0	0	4,000
Midland	0	0	0	0	1,000
Georgetown	0	0	0	0	500
Glasgow	0	1	1	0	200
Total	41	39	16	21	69,400

Woodlawn and East Rochester are newly incorporated boroughs.

The average number of typhoid fever deaths in the Ohio River towns named in the above table for the last four years is 29¼ per annum for the entire population estimated at 69,400. This is equivalent to a death rate of 42 per 100,000 population; but there are hospitals in McKees Rocks, Coraopolis, Ambridge, Rochester and Beaver to which patients are brought from the built-up sections of the townships and from country districts so that at least 80,000 people is the population upon which to base the rate, which would then be 36.5 per annum per 100,000 population, which is lower than the State rate.

Drainage Area.

The Ohio River in Pennsylvania is about 40 miles long; but the Ohio basin occupies practically the whole western portion of Pennsylvania and includes those of the Monongahela and Allegheny rivers. The stream proper is formed at Pittsburg, whence it follows a general northwesterly course for about 25 miles and then turns and flows in a southwesterly course for the balance of the distance to the State line.

The area of the main basin above the Pennsylvania and Ohio State line is 22,854 square miles, of which 11,140 miles are in the Allegheny watershed and 7,329 miles in the Monongahela watershed.

Gradients.

The Monongahela River is slack water for about 125 miles up-stream to Fairmount, West Virginia, and has a more uniform profile than the Allegheny River, which is not slack water. From Pittsburg to the State line there are a series of Government dams six in number. The gradient here is about 1 ft. per mile. From Pittsburg to the Ohio-Indiana line or the mouth of the Great Miami River the Ohio is 487 miles in length and the fall is 271 ft. or 0.056 ft. per mile.

Population on Watershed.

The distribution of the population on the watershed of the Ohio River above the Pennsylvania-Ohio State line is given in the accompanying table by sub-area and total area.

There are two principal points of maximum population density, and maximum sewage pollution of the Ohio River in Pennsylvania. One is Pittsburg and vicinity, as appears by the above table, and the other is Beaver and vicinity, which is not shown by the above table. The population along the river in the former is approximately 583,000 and that in the latter is 18,900. The city of Pittsburg in the year 1900 had a population of 321,616 and Allegheny City had a population of 129,986.

Relation of Concentrated Population to Volume of Flow.

Monthly discharge measurements at Wheeling, W. Va., made by the United States Government for the years 1905 and 1906 are given in the following table:

Year.	Discharge in Second Feet—Maximum.	Minimum.	Mean.	Run-off sec. ft. per sq. mi.
1905	359,600	6,600	44,837	1.87
1906	189,000	4,980	36,000	1.51

In conjunction with the combined population of about 583,000 discharging sewage into the Ohio River at and near Pittsburg, it is evident that the minimum flow of the river of 1,200 sec. ft. is only 2 cu. ft. per sec. for 1,000 of population, a figure which indicates the existence of a nuisance from odor were the sewage to be emptied into the river at one point. The minimum dilution considered permissible is usually taken at 3.33 cu. ft. per sec. for 1,000 persons contributing to such sewage discharge. The fact is, however, that no nuisance from odors is considered by the inhabitants of the river towns to exist to any great extent, although there are complaints about local nuisance at times of extreme low water. The navigation pools minimize the odor trouble and the freshets scour out the deposits of accumulated sewage sediment. But it is apparent that the Allegheny and the Monongahela and the Ohio rivers are seriously polluted by sewage from a water-supply standpoint.

Industrial Development.

The Pittsburg district is noted the world over as the center of the iron and steel industry of the country. However, the establishment of great industrial works on the banks of the Ohio River below Pittsburg to the Ohio line is relatively less than along the Allegheny and Monongahela rivers in the district, but there are some large plants.

In McKees Rocks extensive iron works are located. Five miles further down-stream in the vicinity of Coraopolis are located extensive oil refineries, glass works and machine shops. And six miles further on a large galvanizing works and bridge erecting shops. Opposite this point are the large steel works and galvanizing plant and furnaces of the Jones & Laughlin Co. From this point, at Woodlawn, on to Beaver, both banks of the river are dotted with smaller manufacturing establishments, but from the mouth of the Beaver River to the state line there is little industrial development.

There are some large [in the various towns] works from which spent acids and other manufactural and domestic wastes are discharged. The domestic wastes predominate.

The Monongahela River water is highly freighted with foreign ingredients. The sulphur waters from mine drainage materially contribute to this condition and render the waters acid at times. There are about 400 coal mines in operation on the watershed in Pennsylvania and in West Virginia there are many. The Allegheny River watershed contains 417 coal mines and during droughts for short periods the river at the Aspinwall filter plant contains objectionable amounts of iron and acid, but this happens for a short period only.

Chartiers Creek is a highly acid stream because of the discharge of the drainage from 66 coal mines on its watershed. The waters are unsuitable for domestic purposes, although they are used to some extent for industrial purposes.

Montour Run drainage area has three coal mines upon it. The acidity of the waters of the stream vary according to the discharge from the mines and the season of the year.

The Beaver River has 38 miles on its shed and a number of tin plate mills.

Raccoon Creek has eight coal mines and Little Beaver River has two on the watershed in Pennsylvania.

The improvement of the navigation of the Ohio River by the Federal Government has increased to a marvelous extent the use of the river for freight transportation. Federal appropriations have been granted for slack water improvement between Pittsburg and Cairo. It is not unlikely that cheaper freight rates, especially for coal transportation to the middle west and south, will follow the completion of the improvement of inland waterways. Furthermore, important railroads extend along either bank of the river, and these facilities and the abundance of water as a manufacturing resource offer inducements for the erection of manufacturing establishments on the river banks. The present and future industrial development must necessarily be influenced by the quality of the river water. It has been found, in spite of precautions and warnings taken at the mills, that employees will heedlessly drink the sewage-polluted waters of the Ohio as they pass through the works where they are introduced for cooling and manufacturing purposes only. In this manner many valuable mechanics have contracted water-borne diseases. As skilled labor becomes more valuable so also does the health of the employees become more valuable to the employer. As a public asset from industrial and the health standpoint, the Ohio River water should be preserved in its purity.

Domestic Water-Supply.

There are 37 settlements on the Ohio River in Pennsylvania between Pittsburg and the Pennsylvania-Ohio state line. The water-supplies of these places are grouped in the accompanying table:

OHIO RIVER DISTRICT SUPPLIES CLASSIFIED.

Classification.	Population.	Percentage of total population
Raw water	600	1.0
Cribs and driven wells	3,900	4.5
Filter cribs	12,500	14.5
Driven wells	43,250	50.5
Mechanical filters	10,150	11.8
Ground water	15,150	17.7
	85,550	100.0

82.3% of the total population of 85,550 people are furnished with water whose purity is extensively menaced by the sewage of the district. 17.7% of the population are supplied with ground water that is not known to be menaced by the sewage discharged into the Ohio River. To this population is supplied by the waterworks system every 24 hours a grand total of 18,000,000 gals., of which 43.4% comes from driven wells, 28.4% from filter cribs and 18% from the raw Ohio River.

Manufactural Water-Supply.

There are 53 manufacturing establishments of importance located along the banks of the Ohio River in Pennsylvania below Pittsburg. They afford employment to 28,000 people. The source of supply of water for industrial purposes is principally from the Ohio River and for drinking purposes at the industrial works from deep wells. There are 49,000,000 gals. of water consumed daily for manufacturing purposes, so that for all purposes, manufactural or domestic, the consumption in gallons each 24 hours is 67,000,000, of which 75% is water taken directly from the Ohio River.

As the valley develops industrially, the use of river water is bound to increase. That it is an indispensable resource is evident.

Disposal of Sewage.

The estimated population of the towns along the Ohio in Pennsylvania having sewerage facilities is 77,800, of which 51,000 reside in dwellings connected to the sewers which discharge into the river. A much larger number contribute to the sewerage system during the working hours at some of the industrial plants. The only purification plant in the district is at the Dixmont Insane Asylum. The total length of the sewers is 130 miles.

DISPOSAL OF GARBAGE.

Method.	No. of towns.	Population.
Crematory disposal	7	22,500
Reduction disposal	2	14,300
Incineration disposal	2	16,000
Hauling to country and burial, feeding to hogs, etc	9	14,300
Burial in low ground	2	5,000
Dumped into Ohio River	1	3,500
No system	14	9,950
	37	85,550

Disposal of Night Soil.

Living in the sewered communities of the Ohio River district are 25,000 people who do not use these sewers and there are living in the unsewered districts of the river territory 7,750 people. The disposal of the night soil of the unsewered districts is by methods prevalent throughout farming territory the country over. The disposal of the night soil of the population living in the sewered districts but not connected to the sewer system varies widely. Some of it is burned or removed to the rural sections and there buried, or composted and used as fertilizer, or deposited on bottom land prior to a flood which effects its complete removal or is dumped bodily into some convenient sewer manhole whence it reaches the river. Little night soil is dumped directly into the river because of Federal laws prohibiting such a practice.

Disposal of Manufactural Wastes.

In the following table is given the classification of the industries and the number of hands employed. There are twelve classifications and there are no manufactural wastes from any but 9 steel works, 4 oil refineries, a brewery and a galvanizing plant. In the steel works 49 tons of acids are used monthly and in the oil refineries 66 tons.

DATA RELATING TO INDUSTRIAL PLANTS IN THE RIVER DISTRICT.

Classification.	Plants.	Employees.	Per cent. of total population in district.
Iron and steel and products	26	22,635	80.0
Glass	5	2,500	9.0
Bricks	5	245	1.0
Oil	5	121	0.5
Railroad	4	1,460	5.0
Breweries	2	125	0.5
Miscellaneous	6	1,250	4.0
	53	28,336	100.0

POPULATION ON THE WATERSHED OF THE OHIO RIVER—ABOVE THE PENNSYLVANIA-OHIO STATE LINE—CENSUS 1900.

Watersheds.	Distance from Pittsburg. Miles.	Population.	Approximate Drainage Area—Square Miles In Pa.	Total.	Population per sq. mi.
Monongahela	0	138,432	2,750	7,329	19
Allegheny	0	1,038,398	9,840	11,140	93
Chartiers Creek	2.5	68,102	278	278	245
Montour Run	9.5	3,730	37	37	101
Beaver River	25.5	328,355	1,780	3,120	105
Raccoon Creek	29.5	8,780	184	184	48
Little Beaver Creek	39.0	41,184	100	406	83
Ohio River direct	..	303,922	270	270	1,866
Total watershed	..	2,130,903	15,219	22,964	93

Character of Ohio River Water.

At no point along the Ohio River in Pennsylvania is the river water safe for human consumption unless it be first purified. The amount of sewage discharged into the river is increasing year by year and this is true with respect to manufactural wastes and mine drainage. So far as the Department is informed systematic bacteriological tests of the river water have not been made.

The following comments were made by a chemist of a sample of the Ohio River water. This chemist was familiar with the river and has analyzed many samples.

The permanent hardness denotes the total calcium and magnesium sulphate present and would require about .37-lb. of soda for each 1,000 gals. of water treated. The temporary hardness denotes the calcium bicarbonates and magnesium bicarbonates present, this would give .216-lb. As the present analysis shows .058-gr. of carbonic acid gas per gal., and as carbonic acid requires its equivalent of lime, the total lime would be .27-lb. for each 1,000 gals. of water treated.

So far the samples of the Ohio River water taken about the same time we take samples of the Monongahela River water, shows the Ohio River water to be far superior to the Monongahela, although it would be necessary to have this water treated in order to get ideal water for the boilers.

Annual Convention of the American Society of Agricultural Engineers.

By CHESTER O. REED.*

The American Society of Agricultural Engineers held its fourth Annual Convention Dec. 27 and 28 at Purdue University, Lafayette, Ind., with a good attendance of men engaged in teaching agricultural engineering in our several universities and of manufacturers of agricultural machinery.

It will be remembered that the Society was formed at Madison, Wis., in 1907, the movement being brought about by a realization of the need of organization in a work which presents boundless unexplored fields for needed research. It is a work which has not come by a result of a mere desire for something new—it is a work that has been forced upon our agricultural colleges as a necessity for economic production, as is shown by the demands being made upon the teacher and manufacturer by the wide awake business farmer who realizes that the mechanical problems of rural life have stood unattacked only too long. As he resolves to gnaw at the perplexities confronting him, he seeks aid just where he should find it—through the Society of Agricultural Engineers.

Many papers read at the convention, prepared by men of eminence, emphasized the importance and need for the work that the Society has entered. Dean Skinner, of the Purdue Agricultural College, in his address of welcome called attention to the fact that as farming becomes more and more a business, the farmer is becoming more of a manufacturer, and one of the drawbacks to a better success is the web of problems of an engineering nature which entwines itself about rural activities.

Dr. Samuel Fortier, Chief of Irrigation Investigations, U. S. Department of Agriculture, in a paper on the "Demand for Agricultural Engineering in Irrigated Districts," cited the need of investigation in the branches of agricultural work and expressed a fear that the present systems of education are leading men and women away from the farm and shop to enlist as able lieutenants in corporations and municipalities rather than answering the true purpose for which the Land-Grant Colleges were founded—that of furnishing an education for the man in his work, which will enable him to solve the problems of his occupation. This is true also in the agricultural colleges where an insufficient training is afforded to enable the farmer to surmount his engineering difficulties.

In an eloquent address by Mr. Newall Sanders, of Chattanooga, Tenn., on the "Reconstruction Work of the Agricultural Engineer," the past was reviewed and the future broadly pictured. After this comparison of past and future methods, the speaker said in part:

> Creation and development by natural causes previous to the advent of man were constructive. The work of man in its early stages was destructive. The work now left is largely reconstructive. We have builded in a superficial way and hardly for a lifetime. We should now begin to build for a thousand years. Renewed life has been the dream of man through all ages. Let the renewed life of the farm and the farmer be the dream and work of the agricultural engineer.

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Farm Buildings.

The Farm Building Session was opened by a paper prepared by Prof. F. H. King, of the University of Wisconsin, on the "Ventilation of Farm Buildings." Prof. King called attention to the importance of proper ventilation by mentioning the fact that man can live five weeks without food, five days without water, but scarcely five minutes without air. Extracts from Prof. King's paper follow:

> The process of ventilation consists of (1) forcing air into a space to be ventilated, (2) securing the proper distribution of the air throughout the space ventilated and (3) in removing the air and objectionable products from the space. The continuity of air flow in ventilation is maintained by difference in air pressure. Diffusion is far too low to be made an effective factor in ventilation and it is a mistake to look upon muslin walls, windows, or screens as in any important sense effective ventilation by diffusion.
>
> The problem of ventilation for farm buildings is how to secure amounts of air continuously and of the essential purity for man and our domestic animals. It is a matter of the highest economic and sanitary importance. Until the needful degree of air purity is known, we have no basis upon which to construct and install ventilation systems which shall be qualitative and quantitatively efficient.
>
> While the outtakes should be as few and as large as possible, the intakes should be many and small. The outtakes should exhaust continuously from the floor level and be provided with outlets at the ceiling for use only when the stable is too warm or the ventilation inadequate.

HOLLOW CLAY BLOCKS.—That Mr. M. L. King, Experimentalist at the Iowa State College, is a strong advocate of the use of hollow clay blocks in farm-building construction was evident from his paper on that subject. Mr. King claimed that the advantages of this building material over brick are a lower cost, a less weight, the blocks lay up faster, are poor conductors of heat and cold and require less mortar, with little, if any, sacrifice in strength. It must be remembered, however, that brick are more available, are easier handled, and are more uniform in color.

Farm Machinery.

TRACTION EFFICIENCY.—Mr. L. W. Ellis, of the Rumley Manufacturing Co., opened the Farm Machinery Session with a paper entitled "Traction Efficiency." He said:

> One of the greatest needs in one of the greatest fields in agricultural engineering is that of a standard basis for rating farm tractors. * * * The present lack of uniformity is bewildering to purchasers, most of whom are buying their first engines. The proposal to set an A. S. A. E. standard should meet with hearty approval. It is needless to state that tractors should be rated upon a basis of actual delivered horse-power. Nor can any one object to a standard conservative enough to protect the purchaser from disappointment, the manufacturer from the charge of misrepresentation, and the tractor from abuse through overloading.

The speaker stated that the internal factors governing tractor efficiency are largely settled by the manufacturer, but the external factors, such as a standard fuel, speed influence of grade, road surface, character of load and internal friction, constitute the strongest arguments against the establishment of a standard test.

STANDARDIZATION.—Representatives from the largest concerns manufacturing tractors joined with Mr. Ellis in his plea for a standard test for horse-power ratings. A report of the Committee on "Standardization of Farm Machinery and Farm Tractors and Their Tests" showed that some thought had been given this problem but little has been definitely decided. The committee was reappointed and instructed to draw up empirical formulas for the rating of steam and gas engines. It is hoped that important developments will soon follow.

ELECTRICITY IN AGRICULTURE.—With our minds occupied by a study of things at hand, we are quite apt to live to-day and forget to-morrow. He who dotes on the future is classed as a dreamer, in one sense of the word, but when large manufacturing interests dream, we may rest assured that the fancy has a substantial basis and a realization is soon to follow. Manufacturers have been dreaming of an electrified agriculture for some little time and from a paper on "Electricity in Agriculture," by Mr. M. E. Edwards, of the General Electric Co., we are led to believe that electricity must soon take its place in rural communities as an agent of a more economical and enjoyable agriculture.

After calling attention to the fact that millions of dollars have been expended by agriculturalists in the investigation of plant-life phenomena, whereas relatively nothing except experience has been spent by the farmer for the study of his power problem, Mr. Edwards continued in part:

> We are now rapidly reaching a solution of the problem and a few years more will see the abandonment of century-old and primitive methods that have prevailed, and the substitution of rational, scientific, business principles. The farmer aims to secure the greatest returns from the least investment, and by "returns" is meant financial prosperity, physical comfort and happiness.
>
> Why should the farmer spend money for the study of this problem? Because, as a class, he is our greatest user of power in its many forms, but the power that he uses is not on a par with that of modern progress, considered from the standpoint of efficiency and economy. The writer is not prepared to believe that a sharp dividing line exists between the power needs of our urban and rural population. He does believe that mechanical power can be made to benefit the farmer to the same extent that it has benefited his city brother.
>
> If the farmer can get an electric-lighting plant for a few hundred dollars, why not increase that expenditure by a few hundred dollars more and thereby secure power available for operating milking machinery, separators, churns, refrigerating plants, hay hoists, pumps, wood cutters, feed grinders, threshing machinery, corn shellers, etc., etc., and for his wife electric irons, vacuum cleaners, sewing machines, fans, chafing dishes, etc.?
>
> It appears to the writer that alternating current is best adapted to power applications. It is much more flexible than direct current; it can be transmitted economically to almost any distance desirable and it has one great advantage: If the farmer installs his own plant and later on a public-service corporation extends its lines to his vicinity he can switch over from his isolated plant and benefit through the lower cost of power so obtainable without discarding his motors.
>
> It is evident that the first great strides toward an electrified agriculture will be taken along the interurban trolley lines where power can be purchased and readily used by the installation of transformers. This will lead eventually to the establishment of central power stations and the farmer's isolated plant will have reached the prime of its development.

NEW DYNAMOMETER.—Prof. J. B. Davidson, of the Iowa State College, described in some detail his new dynamometer in which he has successfully combined the desirable features of a convenient means of attachment, a close hitch, variable capacity and adaptability to a wide range of use, and the recording of the average draft over a self-measured run. The instrument will soon appear on the market. Investigators and manufacturers have been handicapped in the past by not having a simple, accurate, and easily-handled machine embodying these features to aid in the study of draft, and the new instrument will find a hearty welcome.

Business Matters.

At the business session a motion was carried that the Society make a recommendation to the Minnesota State Board of Agriculture that a Motor Contest, under the auspices of the Society, be held at the next Minnesota State Fair. The Executive Council was empowered to start negotiation for the accomplishment of a similar contest, open to the World, to be held under the Society's management at the next World's Fair.

A committee was elected, with Prof. P. S. Rose as chairman, to consider the advisability of and affiliation of the Society with the Gas Engine Trades Association. It is hoped that much co-operation will greatly facilitate progress in studying agricultural engineering problems.

It is a significant fact that agricultural engineering is being recognized by the U. S. Department of Agriculture. A resolution was passed asking that a Bureau of Agricultural Engineering be established at Washington to carry on investigations in agricultural engineering.

A second resolution was passed recommending that commercial societies encourage agricultural engineering education and research work in the Land-Grant Colleges.

The officers for the ensuing year are:

President, Prof. C. A. Ocock, University of Wisconsin, Madison, Wis.
First Vice-President, W. F. McGregor, J. O. Case Threshing Machine Co., Racine, Wis.
Second Vice-President, J. B. Bartholomew, Avery Co., Peoria, Ill.
Secretary, Prof. J. B. Davidson, Iowa State College, Ames, Ia.
Treasurer, E. A. White, University of Illinois, Champaign or Urbana, Ill.

The proceedings of the Society may be obtained from the Secretary at Ames, Ia.

A German Balloon Shed of Take-Down Construction.

The two illustrations herewith show a steel shed for housing airships that is quite unique in one respect. It is intended for temporary use wherever it may be needed, and for this purpose is designed for quick erection and without false-work or other auxiliaries of regular erection.

The shed frame consists of three-hinged arch trusses each tied by a tension rod at the foot. They are braced together in pairs by the purlins and diagonal rod bracing. Each truss is made in sections or panels about 20 ft. long, so that the top sections alone will make a small arch; the next lower sections added to them will make a somewhat larger and higher arch, and so on until the full height and span of the structure are reached. The tie rod also is made with intermediate attachments, so that it can be applied to the partly-built arch temporarily during the erection of the structure. By setting up the crown sections with the tie rod holding them, then raising one side of the frame high enough to permit inserting the next lower section, and then tipping the structure in the opposite direction to insert the second section on the other side, and so on progressively, the whole roof can be raised and connected in its full height, without staging, and at the same time will be fully braced and secure in every stage of the erection. The roof covering is canvas, which is easily put on after the frame-work is up.

Fig. 1, showing the frame-work complete on part of the length of the shed and within one panel of completion for the near end, may be compared with Fig. 2, which shows the frame-work in an earlier stage of erection, one side having just been lifted and an additional panel of the arch frame and bracing put in place. In Fig. 2 are seen also the special gantry hoist frames which are used for lifting the roof in its successive operations of erection. These are about 25 ft. high and carry 10-ton chain blocks for doing the lifting. Each gantry frame is somewhat longer than the distance between adjoining arch trusses.

The dimensions of the structure are: span 33 m. (108 ft.); height to crown hinge 30 m. (98 ft.); diameter of inscribed circle 20 m. (65.6 ft.). The shed may be built to any desired length, according to local needs.

The structure was built by the firm of G. Trelenberg, in Breslau, and is owned by the Ballonhallenbau Co., of Charlottenburg, Germany. A brief illustrated description from which we have taken the matter here given is presented in "Der Eisenbau," of November, 1910, in an article by P. Dirksen.

OIL AS FUEL is to be substituted for coal at the Steptoe Smelter, McGill, White Pine County, Nevada, operated by the Nevada Consolidated Copper Co., and the Cumberland Copper Co., subsidiaries of the American Smelting and Refining Co. The oil fuel is to be used in the reverberatory furnaces as well as in the power plant, where electricity is generated for the many motor drives about the concentrator and smelter.

Railway Passenger and Freight Terminals in Large Cities.*

By FREDERIC A. DELANO,† M. Am. Soc. C. E.

The healthy growth of our cities is dependent upon the concurrent growth of adequate transportation facilities. In cities with less than 100,000 inhabitants it is desirable that trains shall deposit their passengers close to the business center of the city. But in larger cities this is no longer possible, and, to my mind, it is highly undesirable.

The reason for this conclusion is that the railway terminal of a large city, if it is to be adequate to the needs, takes up directly and indirectly an immense amount of space, requires the closing of streets, and thus interferes with the growth and development of a city. Railway terminal facilities in a city may be analyzed, in a general way, as follows:

(1) Passenger terminals: (A) for suburban passengers; (B) for through passengers.

(2) Freight terminals: (A) for high-class packages of less-than-carload freight which is now, generally speaking, trucked through the city streets; (B) for the more important carload freight which is also, to a very large extent, trucked through streets or to some extent handled directly from car to warehouse; (C) the coarser articles (like coal, brick, stone, sand, structural steel, lumber, and miscellaneous building materials) which need not necessarily be handled in the heart of the city and which are usually distributed from yards conveniently located about the city.

The public naturally considers the passenger terminal as the all important matter. But, since from 66 to 75% of the earnings of railways are developed from freight business, and practically all our supplies of all kinds, including our daily food, are transported by freight, that branch of the service is of most vital importance.

The planning of adequate and proper freight facilities in our large cities is not only more difficult, but also of more real importance to the life, health and comfort of the people.

If it were possible to separate the suburban or short haul travel from the "through" or long-haul travel, it would be desirable to let the suburban passengers be carried into and through the regular channels or arteries of the intramural scheme of transportation. The kind of metropolitan station which is desirable and necessary for the long-distance business is neither desirable nor necessary for the suburban service.

The suburban passenger should, if possible, reach his business destination without being required to transfer to another system of transportation, but this is neither required nor particularly desirable in the case of the long-distance traveler. The latter usually wishes to go to his home or to his hotel before proceeding to his work.

An analysis of travel usually will show that by far the greater proportion of the users of the long-distance trains live in widely scattered parts of the "fringe" of the city, so that it is a mistake to assume the through passenger terminal must be central to the center of population. A more correct statement would be that it should be near the center of convenience for the principal users.

What the center of convenience is, is a matter of some difficulty to determine. To a large portion of the transient visitors it would bear some relation to the hotel and theater center; to accommodate another large proportion of the traveling public it should be conveniently related to the residence districts, which are usually widely separated.

But in no one of these three cases is it to be expected or necessary that the passenger arriving from or departing on a long journey should do so without taking some conveyance. An analysis of the business will usually show that the large number of passengers arriving and departing on through trains use surface, elevated, or subway cars, cabs, busses, automobiles, or other conveyances. The important question is not that the station shall be within walking distance, but that it shall be conveniently related to these various means of intramural transportation.

The location of a union station or group of stations obviously becomes increasingly more difficult with the number of railways to be dealt with. In Chicago it is an interesting problem because 23 railway systems (28 lines) have their railway terminals here.

We have in Chicago a problem of determining and locating a passenger terminal for lines radiating in 28 different directions. And, as the approaches to Chicago are flat, many of these lines cross and recross each other. To make an ideal and complete readjustment of all these lines would involve too great a destruction of vested interests, but a readjustment and simplification so far as the city terminals alone are concerned is both feasible and desirable.

The writer published suggestions along this line several years ago which, with some modifications, have been given the approval of important interests. This plan contemplates making a series of three to six union stations along a broad avenue to be created on 12th St.*

It may be argued that the companies or groups of companies that have a relative advantage as compared with their neighbors will never agree to such a plan. But not one of these companies (with the possible exception of the Chicago & Northwestern Ry., which is in the midst of making extensive improvements) has all that it requires, and there is not one of these companies or groups of companies which does not require some added facilities, either passenger or freight.

*From a paper in the Chicago "Tribune" of Dec. 14.
†President, Wabash Ry., Chicago.

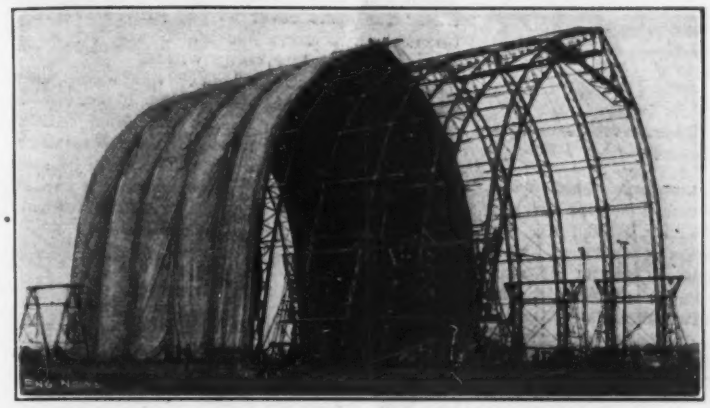

FIG. 1. TAKE-DOWN BALLOON SHED NEARLY COMPLETE.

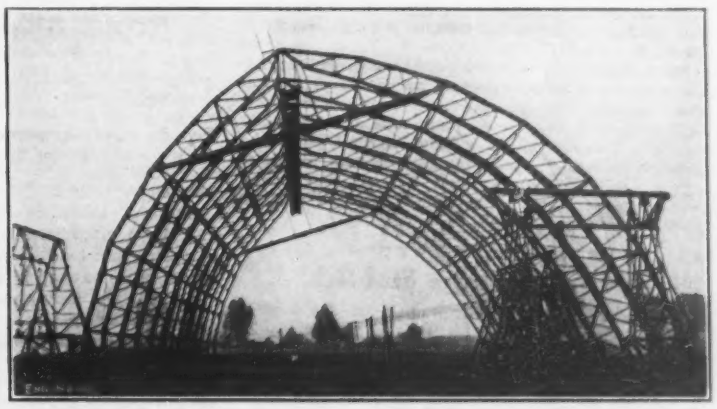

FIG. 2. SHED DURING ERECTION.

Freight Terminal Facilities.

As has been said, the difficulties in planning freight terminals are much greater than with passenger terminals, and there is room for immense improvement and development in this direction.

The old-fashioned method (still almost universally in use) of handling freight from wagons across a covered platform to be loaded into cars is satisfactory in towns and cities of moderate size. But in our large cities, where the congestion of street service is great, causing constant detentions; where the cost of teaming, due to high wages, is excessive; and where, on account of the fact that to make freight facilities adequate, freight houses must be made long, the cost of trucking the freight by hand and the time wasted are both excessive. It seems strange that the first development of our tunnel facilities for transportation in cities should have been for the carriage of passengers. What if we had built our subways first to relieve the surface of the streets of all the slow moving traffic and had reserved the surface of the streets for our own use? Certainly light and fresh air are more necessary for human comfort than for the handling of goods!

Because freight is not self-propelling the cost of gathering and distributing it in a large city is an enormous item. As a result of economic conditions in this country wages are increasing rapidly and the unit of human efficiency without the aid of machinery is diminishing at the same time. These economic conditions have resulted in damage alike to railways and shippers, because no mechanical devices have been found to offset the immense increase in labor cost. All admit that the methods are crude; they are no better than they were 50 years ago, while not nearly so cheap. How to solve the problem is the question.

The passenger station problem where many railways

*Engineering News, Feb. 16, 1905.

are to be dealt with is difficult, but the freight problem is, by comparison, stupendous. In Chicago six passenger stations are handling the 23 separate trunk lines (four of which have more than one line into the city). But each of these 23 lines has at least one downtown station for receiving and forwarding freight, with from three to ten subsidiary stations farther from the heart of the city to supplement the main station.

It is safe to say that the value of the ground utilized by these downtown freight stations and the tracks serving them is not less than $25,000,000 (I believe it is double that). If these facilities accomplished what they were designed to accomplish, economically and satisfactorily either for the transportation company or the shippers, it might be money well spent, but the truth is that this is only partially true.*

Furthermore, the shipper instead of getting the full advantage of having a plurality of lines to ship over, is at added expense as compared with the shipper in a small town with only one or two railways. In the latter case, he may load his wagon with freight for any destinations in the shippers' guide and leave it to the railway company to sort it out and select the appropriate routes. But in the large city of Chicago he has to divide his truck load according to the number of roads for which he has packages. It is for this reason that the shippers say the city needs union freight stations more than it needs union passenger stations.

The ideal way of collecting and distributing freight would be for the municipality to furnish a tunnel or subway under the streets bisecting the wholesale business district. This freight subway should be provided with a platform or conveyor moving intermittently (or continuously) at slow speed, having at intervals of say two to four blocks small stations for the receipt of freight.†

The freight, duly receipted for by authorized agents, would be loaded on the conveyor, where it would remain until delivered and unloaded in a large, commodious, well arranged house for the distribution and loading of freight. The conveyor, as already described, should be arranged to move in a subway loop through the heart of the city, but emerging from that and along some railway right-of-way to a convenient depot or clearing house for loading of freight.

Load Test of a Large Sand-Jack.

In the erection of a steel span in the bridge over the Sitter River on the new Bodensee-Toggenburg Railway in Northern Switzerland, large sand-boxes were used under the steelwork to provide a ready means of lowering the span to the bridge seats. Prior to putting these lowering jacks into use, a load test of one of them was undertaken, to prove its capacity and its ability to lower under load, and especially to obtain definite information about the settlement which different loads would produce.

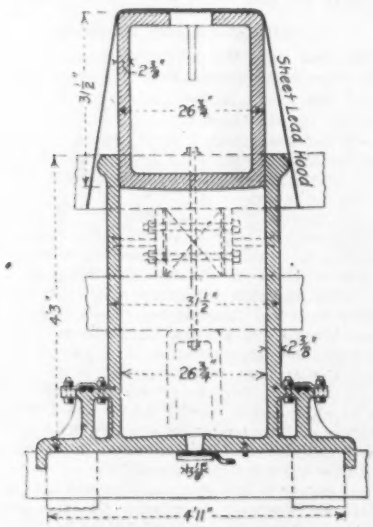

Fig. 1. Vertical Section of Lowering Jack, Sitter River Bridge, Bodensee-Toggenburg Ry., Switzerland.

The construction of the sand-box is shown in vertical section by the sketch Fig. 1 herewith, taken from an article on the erection work by Mr. F. Ackerman in the journal "Der Eisenbau," of November, 1910. The cylinder diameter is 680 mm. (26.8 ins.). The height is about 1,220 mm. (48 ins.) inside, giving a depth of sand of 1 m. (39.4 ins.). The cylinder and ram were smoothly turned and the surfaces greased. The illustration seems to indicate a tight fit, and the text from which we quote makes no mention of clearance.

A hood of sheet lead, as indicated, and grease luting of all joints and crevices were used to protect the sand against moisture. Dry quartz sand which had been used in sandblast work was used for the filling. The escape hole is in the bottom of the cylinder and has a throat diameter of 80 mm. (3.15 ins.).

One of these jacks was tested in a hydraulic press up to a load of 282 tons. The settlement of the ram, that is to say the compression of the sand, was measured at various intermediate loads with the result as set forth in the compression curve (Fig. 2). At the maximum load, which was very closely equivalent to 1,000 lbs. per sq. in., the compression was 65 mm. (2.56 ins.). On releasing the load there was a recovery of 4 mm. (0.16 in.), leaving a permanent set of 61 mm. (2.40 ins.). Reapplying the load brought the compression up to the original figure of 65 mm., showing that the amount of 4 mm. was elastic motion. On opening the gate at the bottom under the maximum load, the sand flowed out slowly and uniformly.

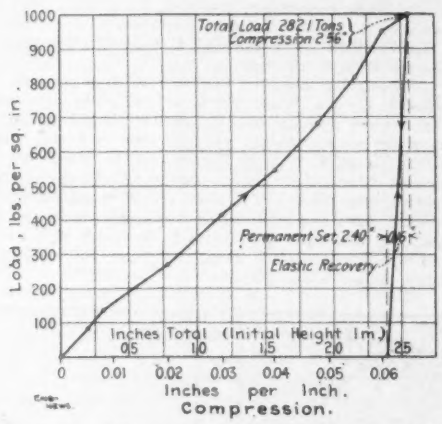

Fig. 2. Load-Compression Diagram for Sand Jack of Sitter Bridge.

In the actual erection work, when the sand-boxes finally lowered the structure to the bridge seats the sand was found to be dry and the boxes operated perfectly. The required amount of lowering was 600 mm. (24 ins.).

The Testing Laboratory of the Bureau of Standards on Structural Materials, Pittsburg, Pa.

[Contributed.]

One of the important functions of the Bureau of Standards, as defined in the organic act which established it, is that pertaining to "the development of physical constants and the properties of materials."

Upon its inauguration the Bureau at once began to lay the foundation for conducting this work in a comprehensive and advanced manner. Realizing the necessity of basing its work on the fundamental standards of length, weight, and other units on which all applied science rests, those departments of its organization were the first to be established, others following in logical order of sequence.

The scientific equipment of the Washington laboratory is now being augmented and extended by additional equipment at the Pittsburg laboratory. At Pittsburg extensive research tests on iron and steel are being provided for, as well as investigative work on cements and concretes, lime, brick and other clay products. The installation of this additional equipment will put the Pittsburg laboratory into condition commensurate with those important interests which it will represent, while the work inaugurated will have direct reference to practical questions on structural engineering, the improvement of current methods and products, and the uses of materials.

In doing this the united resources of both laboratories will be available and the equipment and personnel of the Washington bureau will supplement the resources of the Pittsburg plant.

It is obvious that an efficient laboratory must be prepared to take up the great industrial problems of the country and carry them beyond their present stage of development. This can be accomplished in only one way, namely, by utilizing all allied branches of physical apparatus and concentrating efforts on definite and specific problems. This is the method and policy of the Bureau of Standards.

*See a note on the freight terminal system of Chicago in our issue of Nov. 3 (p. 490).—Ed.

†At Chicago, the electrically operated narrow-gage underground system of the Illinois Tunnel Co., provides for the collection and distribution of freight in small cars.—Ed.

Tests of Voids in Crusher-Run Stone.

By J. R. TAFT,* Assoc. M. Am. Soc. C. E.

Recently the writer had occasion to make a series of tests to determine the percentage of voids in run-of-crusher stone ranging in size from dust up to what would pass a 2-in. screen. The results of the tests are given below.

The stone under test was a Palisade trap, which had been run first through a No. 6 Gates crusher set for a size capable of being handled by a 2-in. rotary screen. Tailings from this screen were fed to a small Reliance crusher which was used solely for this minimum reduction. The tests cover 63 one-yard bucket loads taken from a stone pile which was dry on the outside and slightly damp within.

A one-yard iron tip-bucket was made watertight and when measured found to contain 200 gals. of water. The bucket was filled with the test stone and water added to fill the interstices of the stone. This water was carefully measured when put in, its proportion to the capacity of the bucket indicating the precentage of voids.

The test results are as follows:

Test buckets Nos. 1-29, inclusive, were loaded even full from pile by shovel:

Test No.	Percentage of voids.	Notes.
1	48	Coarse from outside at bottom. No screenings.
2	36	From top of pile outside; large proportion screenings.
3	49	From outside of pile near bottom.
4	43	From top of pile.
5	30	From below surface near bottom of pile.
6	25	Very fine from center of pile.
7	42	Screened stone from near top of pile.
8	32	From near top of pile.
9	45	From bottom of pile outside.
10	24	Very fine from top of pile below surface.
11	40	Coarse from outside near bottom.
12	24	Very fine from inside near top.
13	44	From outside of pile near bottom.
14	21	Large proportion screenings from top of pile.
15	37	From bottom of pile.
16	24	From top of pile.
17	30	From below surface at bottom of pile.
18	28	From top of pile.
19	39	Coarse from bottom of pile outside.
20	30	From top of pile.
21	31	From bottom of pile.
22	28	From top of pile.
23	27	From bottom of pile.
24	27	From top of pile.
25	27	From top of pile.
26	27	From bottom of pile.
27	30	From top of pile.
28	30	From bottom of pile.
29	27	From top of pile.

Test buckets Nos. 30-43, inclusive, were loaded from a similar bucket which had been filled level; surplus above top of test bucket tamped even full:

30	34	Wet stone from outside of pile at bottom.
31	29	From top of pile.
32	27	From top of pile.
33	27	From bottom of pile.
34	36	Coarse from bottom of pile.
35	33	Rather coarse from top of pile.
36	28	Fine from near bottom of pile.
37	39	Coarse from bottom of pile.
38	29	From top of pile.
39	32	From bottom of pile.
40	27	From top of pile.
41	31	From bottom of pile.
42	29	From top of pile.
43	30	From top of pile.

Test buckets Nos. 44-63, inclusive, were loaded loosely from similar bucket and excess above top of test bucket leveled off.

44	36	Loose stone from top of pile.
45	30	Loose stone from top of pile.
46	36	Loose stone from top of pile with some large stone.
47	37	From bottom of pile.
48	36	Below surface at top of pile.
49	33	Below surface at top of pile.
50	30	Fine and dry from top of pile.
51	34	Average stone from center of pile.
52	33	Somewhat fine and dry.
53	36	From top of pile.
54	37	Average stone from center of pile.

*Tyngsborough, Mass.

55	38	Average stone from center of pile.
56	38	Average stone from center of pile
57	40	Quite coarse from center of pile.
58	37	Stone from near center of pile.
59	43	Stone from near center of pile.
60	37	Stone from near center of pile.
61	37	Stone from near center of pile.
62	40	Stone from near center of pile.
63	38	Stone from near center of pile.

SUMMARY.

Showing Percentage of Voids.

	Stone taken from— Top of pile	Bottom pile.	Average.
Test bucket shovel filled.....	30	39	35
Test bucket tamped slightly...	29	35	32
Test bucket loosely filled.....	34	37	36
Total average	31	37	34%

Samples of crusher-run stone were submitted for mechanical laboratory analysis, which showed that 62.5% of the sample was retained on a ⅜-in. screen. Assuming that this size of stone is fairly representative of that found at the bottom of the crusher pile, and applying the average of 37 for the percentage of voids in stone from the bottom of the pile, we find that the voids in the coarse stone of the laboratory specimen amount to 23% of the specimen. In the same way considering the stone from the top of the pile as that passing a ⅜-in. screen, and applying the percentage of 31, we find that the voids in the fine stone amount to 12% of the specimen. This added to the 23 gives 35 for the total percentage of voids in the laboratory specimen. This checks closely the 34% of the summary and seems to verify the result of the entire test.

Notes from Engineering Schools.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.—The number of graduate students in electrical engineering is reported to be steadily increasing so that additional laboratory instructors are being secured. Various lines of research are being carried on. Some of these relate to the effects of heat treatment on the magnetic qualities of silicon iron, certain transient phenomena that may occur in long electric circuits, the effect of high frequencies on the permeability of iron, the effective resistance and reactance of steel rails when conveying alternating currents, the selective action of spark-gap lightning arresters with respect to frequency, the reflection of light from walls or ceilings, the disruptive strength of rubber insulating coatings on wires, etc. Certain of these investigations are continuations of work started last year, and researches in each will be carried on as may be convenient.

The subjects of illumination and photometry, treated from the point of what is commonly called "illuminating engineering," have been added to the electrical engineering curriculum as optional studies.

A FIRE IN A CHURCH near San Luis Potosi, Mexico, Jan. 1, caused the death of 17 of the congregation.

A CHURCH ROOF FELL at Barberton, Ohio, Dec. 26, during erection by volunteer workers from the Barberton Baptist and other churches. About 50 of the amateur carpenters fell with the roof 30 ft. to the ground. One man was killed and 20 others hurt. The building was a temporary one to be used for revival services.

A CENTRIFUGAL MILK TESTER BURST Dec. 29 in the laboratory of the New York State College of Agriculture at Ithaca, N. Y. An instructor and four pupils were severely injured.

A MINE CAR RAN AWAY in a mine of the Red Jacket Coal Co. near Thacker, W. Va., Dec. 31. Eight men were killed and two injured. The car left the rails and is reported to have knocked out some of the mine props causing a heavy fall of coal and rock which crushed the men in the car.

A SURFACE SUBSIDENCE INTO A COAL MINE at Washington, Pa., Dec. 23, wrecked the foundry of Zahnisen Bros. & Sten. The foundry building, 200 × 125 ft., with all its machinery is a complete loss. Some sections of the building are reported to have sunk 150 ft. The coal mine was an old one, abandoned 50 years ago. The loss is estimated at $75,000.

AN EXPLOSION OF BLASTING POWDER, Dec. 28, at the plant of the American Smelter & Refining Co. at El Paso, Texas, killed six men and injured about 20 others. Reports state that more than a ton of the powder was accidentally exploded while the men were engaged in destroying a slag pile.

A BUTTING COLLISION, Jan. 2, on the Miller's Creek Branch of the Chesapeake & Ohio R. R., near Paintsville, Ky., resulted in the death of six trainmen. An accommodation passenger train, according to reports, was struck by a runaway train of coal cars.

A collision of two freight trains on the Baltimore & Ohio R. R., at Mercers Bottom, Mason Co., W. Va., Dec. 27, killed four trainmen. The accident is ascribed to a misinterpretation of train orders.

A BOILER EXPLOSION AT MOREWOOD LAKE, near Pittsfield, Mass., Dec. 29, killed 16 workmen at the plant of the Morewood Ice Co. The boiler was a 50-HP. affair of the fire-tube type, used to furnish power for dragging cakes of ice up the inclines into the storage house. On the morning of the accident there had been some trouble in starting the engine that drove the ice conveyor, and while waiting for repairs to be made about 50 of the workmen went into the boiler-room to keep warm. The accident is attributed to the sticking of the safety valve and steam gage. The safety valve had been placed on the boiler the day before the explosion and set to blow off at 80 lbs.

ANOTHER DYNAMITING OUTRAGE was enacted at Los Angeles, Cal., Dec. 25, when the plant of the Llewellyn Iron Works at Redondo and Main Sts. was damaged to the extent of about $10,000. The front of the main building, a three-story frame structure, was torn out, according to reports, over a breadth of some 75 ft. The interior damage was mainly to the offices on the first and second floors. The explosion occurred at about 2 a. m., when only a night watchman was in the building. The watchman escaped with slight injuries.

FIVE AVIATORS were killed in the week past by falls with aeroplane flyers. On Dec. 28, at Issy, near Paris, France, Marquis Mirio Paolla and Alexander Laffon, Chief Pilot of the Antoinette aviation school, were killed in a 200-ft. fall with an Antoinette monoplane. They were contesting for a $20,000 prize for the fastest flight, with passenger, from Paris to Brussels and return. The machine capsized soon after the start and it is believed that the steering mechanism became jammed.

Lieut. Caumont, of the French Army Aviation Corps, fell from a height of 60 ft. on Dec. 30 at Versailles, while trying out a new monoplane. Both arms and legs were broken and he died in a few hours after the accident.

John B. Moisant was thrown from a Bleriot monoplane near New Orleans, La., on Dec. 31, at the close of a short flight preliminary to an attempt at an endurance record. It is reported that the motor had been shut off and the machine was making a sharp descent when a sudden gust of wind lifted the tail.

Archibald Hoxsey fell 500 ft. with a Wright biplane at Los Angeles on Dec. 31, after giving up an attempt at a new altitude record on account of conflicting air currents. He descended safely from about 7,100 ft. to 500 when his machine overturned.

A DISTANCE RECORD for aeroplane flight was established by Maurice Tabuteau, in contesting for the 1910 Michelin Trophy. In a continuous flight of 7 hrs. 45 min., 362.7 miles were covered. The 1909 trophy was won by Henry Farman by a flight of 150 miles.

THE ELECTRIFICATION OF RAILWAY TERMINALS in Chicago is a subject now under investigation by a committee of the Chicago Association of Commerce. It is being considered, however, mainly from the point of smoke abatement. In fact the committee was appointed particularly for the purpose of considering means for the abatement of the smoke nuisance, so that it has considered other methods besides railway electrification. The original committee, appointed in October, 1909, is composed of the following members: A. Bement, consulting engineer; B. J. Arnold, electrical engineer; A. Bird, city smoke inspector; W. F. M. Goss, University of Illinois (Dean of the College of Engineering); John M. Ewen, contracting engineer; W. B. Jackson, electrical engineer, and Charles E. Merriam, University of Chicago. A report was made in July, 1910, and in December the Association requested the Mayor to appoint some persons to represent the city upon the committee. These new members are Mr. M. F. Foreman, chairman of the council committee on local transportation; Dr. W. A. Evans, Health Commissioner, and Mr. T. E. Donnelly. The enlarged committee will now carry on the work of investigation.

THE CHICAGO FREIGHT TUNNEL SYSTEM, operated by the Illinois Tunnel Co., has now 60 miles of tunnel in operation, forming a network serving the central portion of the city and a number of outlying points. A railway of 16 ins. gage is laid in the tunnels, and the equipment includes 125 electric locomotives and 3,000 cars. One of the latest types of the cars was illustrated in our issue of Nov. 17, 1910. The number of trains in service each day averages 100, and the maximum train load hauled by one locomotive is 30 tons. The tunnel system serves 41 railway freight stations, 4 public stations and 28 warehouses. Freight is delivered and collected also at spurs serving large retail stores, etc. Besides handling general freight, coal is delivered to and ashes are removed from a number of power plants in office buildings and stores.

AN ALUMINUM-MAGNESIUM-COPPER ALLOY known as "Duralumin" and having a high tensile strength with small specific gravity is being used to some extent in Europe for aeroplane engine parts. Cartridge shells made of this alloy are being tested by German military authorities, and the British Government, we are informed, is conducting practical tests to determine its resistance to corrosion in sea water. "Duralumin" is the invention of Mr. A. Wilm, of Berlin, Germany, and consists of more than 90% aluminum alloyed with copper, magnesium and smaller amounts of other materials. It can be rolled cold or hot and can be drawn or forged. It has the color of aluminum and its color is not affected by oxidation. The melting point is about 1,200° F. By varying slightly the proportions of the ingredients, the alloy can be made to show a relatively high elastic limit, or a lower elastic limit with greater hardness. The following data were supplied by Marburg Brothers, engineers and importers, of 1777 Broadway, New York City, to whom we are indebted also for the foregoing information. These data are for soft "Duralumin" plates ¼-in. thick:

	Specific gravity.	Elastic limit, lbs. per sq. in.	Ultimate tensile strength.	Elongation, %.	Contraction, %.
Alloy No. 1....	2.77	26,000	50,000	21	34
Alloy No. 2....	2.84	36,000	63,000	18	26
Rolled	....	74,000	85,000	3	10

GARBAGE COLLECTION AND DISPOSAL in the Canal Zone and in Panama and Colon was described in general terms at some length in the "Canal Record" of Sept. 7, 1910. The two cities named dump the garbage "in a waste place, where it is burned, leaving piles of ashes, and other refuse which serve to build up and reclaim the land." In the Canal Zone preference is given to incineration in furnaces, but in some of the villages garbage is burned on dumps or buried in the earth, while "in the towns bordering on the Chagres River the disposition is easily made by dumping all refuse into that stream," and at Porto Bello all refuse is dumped into the sea. The incinerating furnaces of Balboa, Corozal and Pedro Miguel have been built locally "from ready-to-hand-materials." The other furnaces were bought in the United States mostly from the Morse-Boulger Destructor Co., New York City. The towns having these furnaces are: Miraflores, Paraiso, Culebra, Empire Las Cascadas, Gorgona, Tabernilla and Gatun. As to garbage cans, we quote from the article as follows:

Garbage cans in two sizes, one 25 ins. high and 18 ins. in diameter, and the other 19 ins. high and 15 ins. in diameter, costing on an average about $2.28 and $1.40 each, respectively, are furnished to all business places and dwellings in Colon, and all native houses, stores and employees' quarters in the Canal Zone settlements. In Panama, where the street cleaning and garbage collecting are in the hands of the municipal authorities, containers are provided by the city. These cans are strongly made, the body of 22-gage steel, and the lids and bottoms of 20-gage steel. In addition, they are strengthened with bands around the top and bottom.

MAKING A 6-IN. TAP IN A 10-IN. WATER MAIN, under a pressure of 130 lbs. per sq. in., in very cold weather has recently been successfully accomplished at Little Falls, N. Y. The heavy pressure noted did not interfere with the work, but when the shaft of the tapping machine was withdrawn it was found impossible to shut the gate valve down. Investigation showed that the difficulty was due to the fact that the intense cold, acting upon still water, had partially frozen the water in the main. To overcome the difficulty, the flange bolts of the stuffing box were loosened, thus allowing the water from the main to have a free flow through the valve. This broke the ice that had formed so that after an hour's time the gate valve was successfully closed and the machine taken out, leaving the job satisfactorily completed. The work was done by the Water Works Equipment Co., 50 Church St., New York City, with the aid of the sleeve, valve and tapping machine made by that company.

LOCOMOTIVE WITH CINDER POCKETS on the smokebox are in use on the Shansi Railway (China). The profile is of such character as to necessitate the engines working continuously at full power, and the result of the strong and continued draft is to draw into the smokebox a sufficient quantity of cinders to block the lower rows of tubes. In consequence of this reduction in heating

surface there is a loss of steaming capacity. To improve these conditions, the manager had pockets applied to each side of the lower part of the smokebox. These extend diagonally outwards, and at the outer (lower) end of each is a discharge door. A sprinkler pipe at the upper end provides for extinguishing sparks, to prevent burning out the iron. With a locomotive altered in this way, the power was increased sufficiently to enable eight instead of seven cars to be hauled (20-ton cars); besides this, the coal consumption was reduced, less repair work is required on the tubes and smokebox, and the tubes are easily kept clean. The pockets can be renewed at the roundhouse, without the necessity of sending the engine to the shops. The above information is taken from the December number of the "Revue Generale des Chemins de Fer."

A LARGE NUMBER OF CONCRETE PILES are to be driven in the foundations of the guide walls adjacent to the Gatun Locks at Panama. The "Canal Record" says:

The south or up-stream center guide wall of the Gatun Locks will extend 1,500 ft. from the south guard gate into the lake. About 350 ft. of the wall nearest the lock will be of solid construction, and the remaining 850 ft. will be constructed as a reinforced-concrete cellular wall supported by reinforced-concrete piles driven to depths from 20 to 70 ft.

About 3,500 piles will be needed in the construction of the foundations. One part of cement, one and one-half parts of sand, and three parts of rock will be used in the construction of the piles, and they will be cast on two platforms about 80 ft. wide and 400 ft. long, located on the rock storage pile at New Gatun. The piles will be allowed to remain on the storage pile about six weeks before driving.

Two steam pile drivers of the skid type, having a maximum height above the ground of approximately 93 ft., are under construction. They will be equipped with steam hammers weighing over 10,000 lbs., 5,000 lbs. of which will be in the driving or striking part of the hammer, which will fall 42 ins. and strike 60 blows a minute.

AN UNEXPECTED FIRE TEST of reinforced-concrete construction was had in a fire which recently was discovered in the coal storage bins in the sub-basement of the Tibbs-Hutchins Building, at Minneapolis, Minn. This building, an 8-story and 2-basement reinforced-concrete structure, is used for a dry-goods warehouse. About the first part of last November, shortly after the building was first occupied, a strong odor of gas was noticed and investigation proved it to come from the sub-basement where the coal was stored. It was then found that the entire storage of coal, amounting to some 224 tons, was burning and had probably been burning for some days, without damaging perceptibly the reinforced-concrete partition walls or ceiling which formed the storage bins. The fire could not be extinguished until the coal was removed.

Personals.

Mr. Philip de Clamecy, a consulting engineer of New York City, has been appointed Chief Engineer with the Coffin Valve Co., of Boston, Mass.

Mr. R. Leslie Crocker, for the past fifteen years employed by the Boston Elevated Ry. Co., Olmstead Bros. and H. F. Bryant, of Boston, Mass., has opened an office in the Park Row Bldg., New York City, for the general practice of engineering and surveying.

Mr. T. J. MacCarthy has been appointed City Engineer of Holyoke, Mass., by Mayor White, to succeed Mr. James L. Tighe, M. Am. Soc. C. E., who has been City Engineer for the past 12 years and Engineer of the Holyoke Water Works for the past 19 years.

Mr. Ernest B. McCready, General Manager of the Lehigh Valley Testing Laboratory, has severed his connection with that concern and established the Allentown Testing Laboratory in Allentown, Pa., in the building formerly occupied by the first named laboratory.

Mr. Francis Lee Stuart, M. Am. Soc. C. E., for the past five years Chief Engineer of the Erie R. R., has been appointed Chief Engineer of the Baltimore & Ohio R. R., at Baltimore, Md. Mr. W. J. Harahan, M. Am. Soc. C. E., formerly Assistant to the President of the Erie R. R., has been made Vice-President and Chief Engineer to succeed Mr. Stuart.

Mr. R. S. Fessenden, formerly Chief Engineer of the Kings Hill Extension Irrigation Co., and of the Twin Falls-Raft River Land & Water Co., and Mr. C. L. Huff, Assoc. M. Am. Soc. C. E., formerly Construction Engineer of the Big Lost River Irrigation Co., have formed a partnership for the practice of irrigation and municipal engineering, at Rupert, Idaho.

The Chesapeake & Ohio Ry. has announced the following promotions: Mr. C. C. Walker, formerly General Superintendent of Transportation to Assistant General Manager; Mr. E. P. Goodwin, General Superintendent, to General Superintendent of Transportation; Mr. J. R. Cary, Division Superintendent, to General Superintendent of the West Virginia General Division.

Mr. J. E. Schwitzer, M. Am. Soc. C. E., has been promoted from Assistant Chief Engineer to Chief Engineer of the Canadian Pacific Ry. He will continue to keep his headquarters at Winnipeg, Man. Mr. Schwitzer is a graduate of McGill University, a member of the Canadian Society of Civil Engineers and President of the Winnipeg Society of Engineers. Mr. J. G. Sullivan, M. Am. Soc. C. E., will suceed Mr. Schwitzer as Assistant Chief Engineer at Winnipeg. Mr. Sullivan is at present Assistant Chief Engineer of the eastern lines at Montreal, Que.

Obituary.

William Coutie, M. Am. Chem. Soc., died at his home in Troy, N. Y., on Dec. 27, at the age of 91 years.

George D. Webb, President of the Webb Granite Co., of Worcester, Mass., was killed on Dec. 28, by a fall from a train on the Boston & Albany R. R., between Boston and Worcester. He was a prominent contractor in building work throughout the eastern states. He was identified with a number of other corporations and was an inventor of granite working machinery.

Richard Hendon Smith, an electrical engineer employed by the Westinghouse Electric & Manufacturing Co., of Pittsburg, Pa., was killed by a live electric wire at the works of the company at Pittsburg on Dec. 29. Mr. Smith was the son of Rev. William H. Smith, of Belair, Md. He was a graduate of Lehigh University in the class of 1905. Besides his father, he leaves a wife and two sisters.

John Galt, M. Can. Soc. C. E., died in Vernon, B. C., on Dec. 20. He was 57 years old and a native of Scotland. He came to Canada about 30 years ago and formed a partnership for the practice of civil engineering with Mr. O. W. Smith in Toronto. Later the firm was dissolved and Mr. Galt became City Engineer at Ottawa. A few years ago he was obliged to go to British Columbia for his health, as he was then suffering from consumption. He is survived by a wife and several children.

Gustavus C. Henning, M. Am. Soc. M. E., of New York City, died at his home in this city on Dec. 30. He was born in Brooklyn, N. Y., in 1855. He was educated at Brooklyn Polytechnic Institute and Stevens Institute of Technology, where he graduated in 1876. He then became inspector under the late William Hildenbrand on the construction of the Brooklyn Bridge. He traveled extensively abroad to introduce American testing machines, some of which were of his own invention. He had for many years an extensive consulting practice in New York and had come to be recognized as an authority on iron and steel. He was a member of the International Association for Testing Materials, the American Institute of Mining Engineers, the American Society for the Advancement of Science, the Iron and Steel Institute of Great Britain and the Iron and Steel Institute of America.

Engineering Societies.

COMING MEETINGS.

MICHIGAN ENGINEERING SOCIETY.
Jan. 10-12. Annual meeting at Lansing, Mich. Secy., Alba L. Holmes, Grand Rapids, Mich.

INDIANA ENGINEERING SOCIETY.
Jan. 12-14. Annual meeting at Indianapolis, Ind. Secy., Charles Brossmann, Indianapolis, Ind.

MONTANA SOCIETY OF ENGINEERS.
Jan. 12-14. Annual meeting at Helena, Mont. Secy., Clinton H. Moore, Leyson Block, Butte, Mont.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.
Jan. 17. Annual meeting at Pittsburg, Pa. Secy., Elmer K. Hiles, 803 Fulton Bldg., Pittsburg, Pa.

AMERICAN INSTITUTE OF ARCHITECTS.
Jan. 17-19. Annual convention at San Francisco, Cal. Secy., Glenn Brown, the Octagon, Washington, D. C.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 18-19. Annual meeting at New York City. Secy., Charles Warren Hunt, 220 West 57th St., New York City.

ILLUMINATING ENGINEERING SOCIETY.
Jan. 20. Annual meeting at New York City. Secy., P. S. Millar, 29 West 39th St., New York City.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
Jan. 24-26. Annual meeting at New York City. Secy., W. M. Mackay, P. O. Box 1818, New York City.

OHIO ENGINEERING SOCIETY.
Jan. 24-26. Annual meeting at Columbus, Ohio. Secy., O. J. Knisely, New Philadelphia, Ohio.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.
Jan. 25-27. Annual meeting at East St. Louis, Ill. Secy., E. R. R. Tratman, 1036 Monadnock Block, Chicago, Ill.

NATIONAL BRICK MANUFACTURERS' ASSOCIATION.
Feb. 6-11. Annual convention at Louisville, Ky. Secy., T. A. Randall, Indianapolis, Ind.

NEW ENGLAND ASSOCIATION OF GAS ENGINEERS.
Feb. 15. Annual meeting at Boston, Mass. Secy., N. W. Gifford, 26 Central Square, East Boston, Mass.

NATIONAL ELECTRIC LIGHT ASSOCIATION.—The membership on Dec. 12 had reached the total of 6,007. The net growth in membership in the year 1910 was about 1,500.

PACIFIC NORTHWEST SOCIETY OF ENGINEERS.—The annual meeting will be held Jan. 7 at Seattle, Wash. The Secretary, is Mr. A. H. Dimock, City Engineer's Office, Seattle, Wash.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—At the meeting in New York City, Jan. 10, Mr. Samuel B. Fowler, of Boston, Mass., will present a paper on "The Mechanical Handling of Freight."

CANADIAN CEMENT AND CONCRETE ASSOCIATION.—The annual convention and exhibition will be held at the St. Lawrence Arena, Toronto, Ont., March 6-11, 1911, instead of in January, as was formerly announced.

ENGINEERS CLUB OF CINCINNATI.—At the annual meeting Dec. 15, officers were elected as follows: President, Charles H. Meeds; Vice-President, John T. Faig; Secretary-Treasurer, E. A. Gast; Directors, J. C. Lemon, C. E. Rasinsky and Herman Schneider.

ENGINEERS' CLUB OF ST. LOUIS.—At the regular meeting of Jan. 4, Mr. M. L. Byers, Chief Engineer of Maintenance of Way of the Missouri Pacific & Iron Mountain Ry., presented a paper entitled "An Analysis of Certain Relations Between the Industrial Corporation and the Consumer."

NEW ENGLAND WATER WORKS ASSOCIATION.—The program for the annual meeting at Boston, Mass., Jan. 11, has been announced as follows: Reports of committees on Conservation, Development and Utilization of National Resources, Chairman, M. N. Baker, New York City; Standard Specifications for Fire Hydrants, Chairman, H. O. Lacount, Boston, Mass.; Extensions of Water Mains in Town Owned Water Supplies, Chairman, Charles W. Sherman, Boston, Mass.; Uniformity of Hose and Gate-Nuts, Chairman, Frank L. Fuller, Boston, Mass.; Awards Made in Water-Works Valuation Cases, Chairman, H. W. Dean, Boston, Mass.; Library, Chairman, Charles W. Sherman, Boston, Mass. A paper will be presented on "The Gas Producer Pumping Plants at Manchester, Mass." by Raymond C. Allen, Manchester, Mass.

THE INDIANA ENGINEERING SOCIETY.—The preliminary program for the annual meeting at Indianapolis, Jan. 12-14, includes the following papers and committee reports: "Coal Handling in Power Plants," T. R. H. Daniel; "Individual Electric Drives Applied to Textile Mills," Charles A. Tripp; "Methods of Standardizing Coal Mine Surveys," A. N. Ogle; Report of Committee on Materials of Construction, Chairman, Prof. W. K. Hatt; "Strength and Expansion of Creosoted Paving Blocks," Prof. W. K. Hatt; "The Manufacture of Portland Cement," C. W. Boynton; Report of Committee on Stream Pollution, Chairman, Prof. R. L. Sackett; "Garbage and Refuse Collections and Disposal," Charles C. Brown; "The Proposed Wabash-Patoka River Levee in Posey, Gibson and Pike Counties," E. E. Watts; "Recent Tendencies in English Sewage Purification Works," Prof. R. L. Sackett; "Portales, New Mexico, Irrigation Project," R. P. Woods; ',The Williams Hydro Electric Plant at Bedford, Ind.," DeWitt V. Moore; "Effect of Boiler Scale at Vincennes Electric Lighting Plant," Leonard F. Metcalf; "Roads and Road Building Methods," Prof. R. L. Sackett; Report of Legislative Committee, Chairman, Charles C. Brown; "Good Roads for Indiana," John O. Potter; "Modern Block Pavement for Bridges in Indiana," Prof. Albert Smith; "Standardization of a Testing Rattler," M. W. Blair; "The New McKinley Bridge Over the Mississippi," J. D. Knapp; "The Use of Upsets and Loop Eyes on Steel Rods in Bridges," Prof. Malverd A. Howe; "New Concrete and Cement Testing Laboratory at Purdue," Prof. W. K. Hatt; "Cost Data of Reinforced Concrete Pipe," W. S. Moore; "Strength of Concrete Building Blocks," Prof. H. H. Schofield.

AMERICAN ASSOCIATION FOR HIGHWAY IMPROVEMENT.—An organization under this name was effected at Washington, D. C., Nov. 22, 1910, and the following officers were elected: President, L. W. Page, Director, U. S. Public Road Office; Vice-President, W. C. Brown, President New York Central Lines; Treasurer, Lee McClung, Treasurer of the United States; Secretary, J. E. Pennypacker, Jr., Colorado Bldg., Washington, D. C. Its avowed purposes are as follows:

To correlate and harmonize the efforts of all existing organizations working for road improvement.

To arouse and stimulate sentiment for road improvement.

To strive for wise, equitable and uniform road legislation in every state.

To aid in bringing about efficient road administration in the states and their subdivisions, involving the introduction of skilled supervision and the elimination of politics from the management of the public roads.

To seek continuous and systematic maintenance of all roads, the classification of all roads according to traffic requirements, payment of road taxes in cash, and adoption of the principle of state aid and state supervision.

To advocate the correlation of all road construction so that the important roads of each county shall connect with those of the adjoining counties and the important roads of each state shall connect with those of adjoining states.

The Association hopes to invoke the cooperation of the press and other agencies in making its work effective. The annual dues for regular membership are to be $5 and "sustaining members" will pay $100 annual dues. All members of state and other organizations for road improvement, cooperating with this Association, are eligible for associate membership, of which no dues are required. Associated organizations are entitled to one vote for each 50 of their members; but associate members, although entitled to participate in discussions, are not allowed to vote as individuals.